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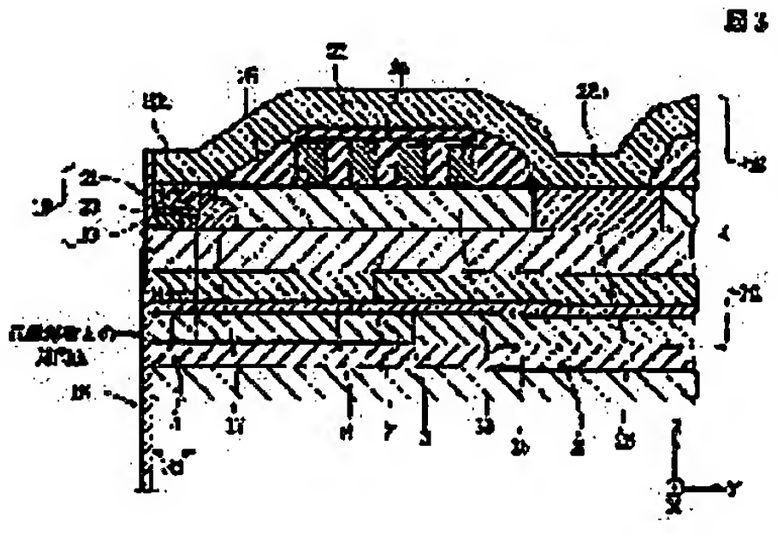
(54) SOFT MAGNETIC FILM, THIN FILM MAGNETIC HEAD USING THE FILM, METHOD OF MANUFACTURING THE FILM, AND METHOD OF MANUFACTURING THE MAGNETIC HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To solve the problem in the conventional FeNi alloy which is not capable of meeting all requirements such as high saturation magnetic flux density, low stress, and low coercive force and not capable of manufacturing a thin film magnetic head that can cope with the future trend of increase in recording density.
SOLUTION: A lower magnetic pole layer 19 and/or an upper magnetic pole layer 21 are formed of FeNi alloy film by plating. The FeNi alloy film contains 55 to below 75 mass% Fe preferably 68 to 80 mass% Fe, and furthermore 0.116 to below 0.140 mass% S or 0.125 to 0.132 mass% S. By this setup, a thin film magnetic head which is capable of coping properly with an increase in recording density and excellent in corrosion resistance can be manufactured.



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CLAIMS

[Claim(s)]
[Claim 1] Soft magnetism film which it is a FeNi system alloy containing S, and the presentation ratio of S exceeds 0.116 mass %, and is characterized by being under 0.140 mass %.
[Claim 2] Soft magnetism film according to claim 1 whose presentation ratio of said S is more than 0.126 mass %.
[Claim 3] Soft magnetism film according to claim 1 whose presentation ratio of said S is below 0.132 mass % above 0.125 mass %.
[Claim 4] Soft magnetism film according to claim 1 to 3 which the presentation ratio of Fe exceeds 55 mass %, and is under 75 mass %.
[Claim 5] Soft magnetism film according to claim 4 said whose presentation ratio of Fe is more than 72 mass %.
[Claim 6] Soft magnetism film according to claim 1 to 3 said whose presentation ratio of Fe is below 80 mass % above 68 mass %.
[Claim 7] It is the thin film magnetic head characterized by being formed by the soft magnetism film by which one [at least] core layer was indicated by claim 1 thru/or either of 6 in the thin film magnetic head which has the lower core layer made from a magnetic material, the up core layer formed through the magnetic gap on said lower core layer, and the coil layer which gives a record field to both core layers.
[Claim 8] The thin film magnetic head according to claim 7 in which the bosselation of the lower magnetic pole layer is carried out by the opposed face with a record medium on said lower core layer, and said lower magnetic pole layer is formed with said soft magnetism film.
[Claim 9] It is located between a lower core layer and an up core layer, and said lower core layer and up core layer, and has the magnetic pole section by which the width method of the truck cross direction was regulated shorter than said lower core layer and an up core layer. The lower magnetic pole layer in which said magnetic pole section follows a lower core layer, the up magnetic pole layer which follows an up core layer, It consists of said lower magnetic pole layer and a gap layer located between said up magnetic pole layers. And or said magnetic pole section It is the thin film magnetic head which consists of gap layers located between the up magnetic pole layer which follows an up core layer, and said up magnetic pole layer and lower core layer, and is characterized by forming said up magnetic pole layer and/or the lower magnetic pole layer by the soft magnetism film indicated by claim 1 thru/or either of 6.
[Claim 10] The up core layer which said up magnetic pole layer is formed by said soft magnetism film, and is formed on said up magnetic pole layer is the thin film magnetic head according to claim 9 formed by the soft magnetism film which has the saturation magnetic flux density Bs lower than said up magnetic pole layer.
[Claim 11] For said core layer, the magnetic layer which the part which adjoins a magnetic gap at least consists of the magnetic layer more than two-layer, or said magnetic pole layer consists of the magnetic layer more than two-layer, and touches said magnetic gap among said magnetic layers is the thin film magnetic head according to claim 7 to 10 currently formed with said soft magnetism film.
[Claim 12] Other magnetic layers except touching said magnetic gap layer are the thin film

magnetic head according to claim 11 formed by the soft magnetism film which has the saturation magnetic flux density Bs lower than the magnetic layer which touches said magnetic gap layer.
[Claim 13] The manufacture approach of the soft magnetism film characterized by carrying out plating formation of the soft magnetism film which it is the approach of forming the FeNi system alloy containing S with electrolysis plating, and the plating bath used like electrolysis galvanizer is made to contain Fe ion, nickel ion, and S ion, dicarboxylic acid is further added during this plating bath, and the presentation ratio of S exceeds 0.116 mass %, and becomes under 0.140 mass %.
[Claim 14] Said dicarboxylic acid is the manufacture approach of the soft magnetism film according to claim 13 which is the sodium tartrate, there is and makes the addition of said sodium tartrate less than 100 mmol/L rather than 37 mmol/L to said whole plating bath. [much]
[Claim 15] Said dicarboxylic acid is the manufacture approach of the soft magnetism film according to claim 13 which is the sodium tartrate and makes the addition of said sodium tartrate 82 or less mmol/L by 62 or more mmol/L to said whole plating bath.
[Claim 16] The manufacture approach of the soft magnetism film according to claim 15 that the presentation ratio of said S carries out plating formation of the soft magnetism film which becomes below 0.132 mass % above 0.125 mass %.
[Claim 17] The manufacture approach of the soft magnetism film according to claim 13 to 16 which mixes saccharin sodium during a plating bath.
[Claim 18] The manufacture approach of the soft magnetism film according to claim 13 to 17 which carries out plating formation of said soft magnetism film with electrolysis plating using pulse current.
[Claim 19] The manufacture approach of the thin film magnetic head characterized by to carry out plating formation of said up core layer and/or the lower core layer in the manufacture approach of the thin film magnetic head of having said lower core layer, the up core layer which counters through a magnetic gap, and the coil layer which guides a record field to both core layers, with the soft magnetism film formed by the manufacture approach indicated by claim 13 thru/or either of 18 at the lower core layer made from a magnetic material, and an opposed face with a record medium.
[Claim 20] The manufacture approach of the thin film magnetic head according to claim 19 which carries out the bosselation of the lower magnetic pole layer by the opposed face with a record medium on said lower core layer, and carries out plating formation of said lower magnetic pole layer with said soft magnetism film at this time.
[Claim 21] It is located between a lower core layer and an up core layer, and said lower core layer and up core layer, and has the magnetic pole section by which the width method of the truck cross direction was regulated shorter than said lower core layer and an up core layer. The lower magnetic pole layer which follows a lower core layer in said magnetic pole section, the up magnetic pole layer which follows an up core layer, It forms in said lower magnetic pole layer and the gap layer located between said up magnetic pole layers. And or said magnetic pole section It forms in the gap layer located between the up magnetic pole layer which follows an up core layer, and said up magnetic pole layer and lower core layer. The manufacture approach of the thin film magnetic head characterized by carrying out plating formation of said up magnetic pole layer and/or the lower magnetic pole layer with the soft magnetism film formed by the manufacture approach indicated by claim 13 thru/or either of 18.
[Claim 22] The manufacture approach of the thin film magnetic head according to claim 21 which forms the up core layer which carries out plating formation of said up magnetic pole layer by said soft magnetism film, and is formed on said up magnetic pole layer by the soft magnetism film which has the saturation magnetic flux density Bs lower than said up magnetic pole layer.
[Claim 23] The manufacture approach of the thin film magnetic head according to claim 19 to 22 which carries out plating formation of the magnetic layer which forms the part of said core layer which adjoins a magnetic gap at least by the magnetic layer more than two-layer, or forms said magnetic pole layer by the magnetic layer more than two-layer, and touches said magnetic gap among said magnetic layers with said soft magnetism film.
[Claim 24] The manufacture approach of the thin film magnetic head according to claim 23 formed by the soft magnetism film which has the saturation magnetic flux density Bs lower than the

magnetic layer which touches said magnetic gap layer in other magnetic layers except touching said magnetic gap layer.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] With respect to the soft magnetism film which consists of a FeNi system alloy, especially, this inventions are low stress and the low coercive force Hc, and relate to the soft magnetism film which has the still higher saturation magnetic flux density Bs.
[0002]
[Description of the Prior Art] The soft magnetism film which has the conventional high saturation magnetic flux density was a FeNi system alloy about 55 mass % and whose presentation ratio of nickel the presentation ratio of Fe is about 45 mass %s, and saturation magnetic flux density Bs was about 1.6T.
[0003] Said FeNi system alloy is used for the core layer of for example, the thin film magnetic head. Improvement in the saturation magnetic flux density Bs of said core layer is indispensable, and the saturation magnetic flux density Bs higher than before was required of the soft magnetism film used for said core layer in order to correspond to future high recording density-ization, and to raise recording density.
[0004]
[Problem(s) to be Solved by the Invention] The soft magnetism film which consists of a FeNi system alloy can raise saturation magnetic flux density Bs by raising the presentation ratio of Fe.
[0005] However, by the soft magnetism film of a FeNi system alloy, while saturation magnetic flux density Bs could be raised with the increment in the presentation ratio of Fe, it turned out that stress (stress) becomes large. For example, the stress which was about 110 MPa extent when the presentation ratio of Fe was 55 mass % will become large even at about 190 MPa(s), if the presentation ratio of Fe becomes 68 mass %.
[0006] When such soft magnetism film of high stress is used for the core layer of the thin film magnetic head, said core layer 7 tends to exfoliate and becomes what has the low dependability of the thin film magnetic head. Although it was requested that the FeNi system alloy which has the saturation magnetic flux density Bs high in this way could be used in order to have been able to secure saturation magnetic flux density Bs T or more [1.8] and to have corresponded to future high recording density-ization, when carrying out Fe presentation ratio especially more than 68 mass % Since very high stress occurs while the high saturation magnetic flux density Bs is securable, it is hard to use it as a core layer. Especially recently For example in the very narrow width-of-recording-track space below of 0.5 micrometer around as it follows on high recording density-ization In order to carry out plating formation of the magnetic layer and to carry out suitable plating growth in such narrow space, if it has the above high stress especially, film peeling appears notably and cannot manufacture the thin film magnetic head which can respond with sufficient repeatability suitable for narrow-track-izing.
[0007] It is thought that it will fall if the stress of the soft magnetism film which consists of a NiFe alloy has the large diameter of average crystal grain of the soft magnetism film. The diameter of average crystal grain of the soft magnetism film can be controlled by the conditions like electrolysis galvanizer, when forming the soft magnetism film with electrolysis plating.
[0008] However, if the diameter of average crystal grain of the soft magnetism film is large,

coercive force Hc will increase shortly. That is, it is thought between said stress and coercive force Hc that the relation of a trade-off is realized.
[0009] Drawing 21 is the graph which showed the relation between the stress of a NiFe system alloy, and coercive force Hc. As for all the samples used for this experiment, the presentation ratio of Fe is made into about 72 mass %.
[0010] As shown in drawing 21 , when stress declines, it turns out that coercive force Hc increases conversely. The increment in coercive force Hc will have a bad influence on soft magnetic characteristics, such as the saturation magnetic flux density Bs of the soft magnetism film, and an anisotropy field Hk, and said soft magnetism film will deteriorate. For this reason, the soft magnetism film used for the core layer of the thin film magnetic head is asked for the lowest possible coercive force Hc.
[0011] as mentioned above -- although saturation magnetic flux density Bs is high on the soft magnetism film used as a core layer of the thin film magnetic head and it is moreover asked for stress and coercive force Hc being low with a raise in future recording density -- the former -- all them -- a ****** FeNi system alloy was not able to be manufactured.
[0012] Then, this invention aims at offering the thin film magnetic head which can respond to high recording density-ization using the soft magnetism film and this soft magnetism film of the FeNi system alloy which is for solving the above-mentioned conventional technical problem, and is the high saturation magnetic flux density Bs, and can realize low stress and low coercive force Hc.
[0013] Moreover, this invention aims at offering the manufacture approach of addition of dicarboxylic acid, and the soft magnetism film with possible being the high saturation magnetic flux density Bs, and easy moreover repeatability improving the FeNi system alloy of low stress and the low coercive force Hc further, plating formation by amelioration of electrolysis plating etc., and the manufacture approach of said thin film magnetic head during a plating bath.
[0014]
[Means for Solving the Problem] The soft magnetism film of this invention is a FeNi system alloy containing S, and the presentation ratio of S exceeds 0.116 mass %, and it is under 0.140 mass %.
[0015] Since magnetism is borne by nickel and Fe and both coercive force Hc and stress decline with the increment in the presentation ratio of Element S, such soft magnetism film is compatible in low stress and outstanding soft magnetic characteristics. Moreover, since an anisotropy field goes up with the increment in the presentation ratio of Element S, soft magnetic characteristics improve.
[0016] On the other hand, by such soft magnetism film, it can consider as low stress and outstanding soft magnetic characteristics, holding the high saturation magnetic flux density Bs, since saturation magnetic flux density Bs was not influenced [big] by the presentation ratio of Element S.
[0017] If the presentation ratio of Element S is made below into 0.116 mass %, the fall of coercive force Hc and stress will not be seen, and if it carries out to more than 0.140 mass %, ****** of a film surface will become severe. When ****** was severe, for example said soft magnetism film is used as core material of the thin film magnetic head, since it becomes easy for thickness of the gap layer formed on it not being kept constant, but it becoming easy to change the gap length decided by thickness of said gap layer, and a predetermined magnetic pole configuration's not being formed and corrosion resistance to fall, it is not desirable. For this reason, it is necessary to make ****** of the film surface of the soft magnetism film as small as possible. According to this invention, 200A or less of center line average-of-roughness-height Ra of the film surface of the soft magnetism film which is above-mentioned presentation within the limits, and was formed can be more preferably made in general into 80A or less.
[0018] In addition, as for the presentation ratio of said S of said soft magnetism film, in this invention, it is desirable that it is more than 0.126 mass %. By such soft magnetism film, the both sides of stress and coercive force Hc can be reduced effectively.
[0019] Moreover, in this invention, it is desirable that the presentation ratio of said S is below 0.132 mass % above 0.125 mass %. According to the below-mentioned experimental result, stress can be carried out in general to it being this presentation within the limits at 160 or less MPas. Moreover, the coercive force Hc of the direction of an easy axis can be suppressed in general for

the coercive force Hc of the direction of a hard axis below to 270 (A/m) below 470 (A/m). Thus, the fall of stress and coercive force can be aimed at still more effectively. Moreover, ****** can be appropriately made small and it is checked in the below-mentioned experiment that center line average-of-roughness-height Ra of the film surface of the soft magnetism film which is above-mentioned presentation within the limits, and was formed can be made in general into 80A or less.
[0020] Moreover, said presentation ratio of Fe exceeds 55 mass %, and, as for said soft magnetism film of this invention, it is desirable that it is below 75 mass %.
[0021] One of the important properties for which a FeNi system alloy is asked is the high saturation magnetic flux density Bs. It turns out that the saturation magnetic flux density Bs of a FeNi system alloy can be raised by making the presentation ratio of Fe increase as already explained.
[0022] According to this invention, the presentation ratio of Fe can obtain the high saturation magnetic flux density Bs by making [more] Fe presentation ratio than 55 mass % compared with the conventional FeNi system alloy which was 55 mass % extent. And in this invention, maintaining the high saturation magnetic flux density Bs, if it is the content of the above-mentioned element S, stress is low and can offer the FeNi system alloy of the low coercive force Hc. Moreover, plating formation of the FeNi system alloy which has a predetermined presentation ratio easily with presentation ratio of Fe electrolysis-plating using below 75 mass %, then the pulse current mentioned later can be carried out.
[0023] In addition, by making [more] Fe presentation ratio than 55 mass %, it becomes possible to carry out saturation magnetic flux density Bs more than 1.6T.
[0024] Moreover, as for the soft magnetism film of this invention, it is desirable that said presentation ratio of Fe is more than 72 mass %. By such soft magnetism film, saturation magnetic flux density Bs can exceed 1.8T, and can obtain the high saturation magnetic flux density Bs beyond 1.9T depending on a presentation ratio.
[0025] Moreover, in this invention, it is desirable that said presentation ratio of Fe is below 80 mass % above 68 mass %.
[0026] If said presentation ratio of Fe is carried out more than 68 mass %, saturation magnetic flux density Bs can be carried out more than 1.8T.
[0027] In this invention, maintaining the high saturation magnetic flux density Bs beyond 1.8T, even if it adds the element S of the presentation range described above into the FeNi system alloy, by addition of said element S, stress can be made low and, moreover, the FeNi system alloy of the low coercive force Hc can be offered.
[0028] However, it becomes [stress becomes large and] easy to cause film peeling also by addition of Element S and is not desirable if Fe presentation ratio increases more than 80 mass %. Moreover, if Fe presentation ratio is carried out more than 80 mass %, since it will become easy for increase of the coercive force Hc accompanying increase of the diameter of crystal grain and soft magnetic characteristics, such as saturation magnetic flux density Bs, to fall, in this invention, said amount of Fe(s) has been set below to 80 mass %.
[0029] Moreover, in the thin film magnetic head in which this invention has the lower core layer made from a magnetic material, the up core layer formed through the magnetic gap on said lower core layer, and the coil layer which gives a record field to both core layers, one [at least] core layer is characterized by being formed by the soft magnetism film indicated by above either.
[0030] It is desirable that the bosselation of the lower magnetic pole layer is carried out by the opposed face with a record medium on said lower core layer, and said lower magnetic pole layer is formed with said soft magnetism film in this invention.
[0031] Moreover, this invention is located between a lower core layer and an up core layer, and said lower core layer and up core layer, and has the magnetic pole section by which the width method of the truck cross direction was regulated shorter than said lower core layer and an up core layer. The lower magnetic pole layer in which said magnetic pole section follows a lower core layer, the up magnetic pole layer which follows an up core layer, It consists of said lower magnetic pole layer and a gap layer located between said up magnetic pole layers. And or said magnetic pole section It consists of gap layers located between the up magnetic pole layer which follows an up core layer, and said up magnetic pole layer and lower core layer, and said up magnetic pole layer

and/or a lower magnetic pole layer are characterized by being formed by the soft magnetism film indicated by above either.
[0032] As for the up core layer which said up magnetic pole layer is formed by said soft magnetism film, and is formed on said up magnetic pole layer in this invention, it is desirable to be formed by the soft magnetism film which has the saturation magnetic flux density Bs lower than said up magnetic pole layer.
[0033] Moreover, it is desirable that the magnetic layer which the part in which said core layer adjoins a magnetic gap at least at this invention consists of the magnetic layer more than two-layer, or said magnetic pole layer consists of the magnetic layer more than two-layer, and touches said magnetic gap among said magnetic layers is formed with said soft magnetism film.
[0034] As for other magnetic layers except touching said magnetic gap layer, at this time, it is desirable to be formed by the soft magnetism film which has the saturation magnetic flux density Bs lower than the magnetic layer which touches said magnetic gap layer.
[0035] Rather than 0.116 mass %, there is much soft magnetism film in this invention, and it contains the element S of under 0.140 mass %. Or it is the FeNi system alloy which contains the element S below 0.132 mass % above 0.125 mass %, and is making many Fe(s) under into 75 mass %, and making them below into 80 mass % preferably rather than 55 mass %, further, above 68 mass %. It can consider as the soft magnetism film which can secure low stress and the low coercive force Hc, maintaining the high saturation magnetic flux density Bs compared with the former. Moreover, by this soft magnetism film, ****** of a film surface can be made small.
[0036] Although the structure which prepared said core layer independently exists variously the structure where an up core layer counters a lower core layer through a gap layer, and the magnetic pole layer for regulating the width of recording track between said lower core layer and a lower core layer developed that it should correspond to high recording density-ization appropriately in the structure of the thin film magnetic head Are necessary to set still more preferably 1.0 micrometers or less of width of recording track Tw as 0.5 micrometers or less that it should correspond to high recording density-ization. Not only soft magnetic characteristics but the film properties of having excelled [saturation magnetic flux density / Bs / high] in the magnetic layer formed in such very narrow space, such as low stress and reduction of ******, serve as an indispensable element.
[0037] When it has high saturation magnetic flux density and ****** uses the small FeNi system alloy of this invention as the core layer and magnetic pole layer of the thin film magnetic head with low stress from such a thing Since stress and ****** can be made small while being able to enlarge saturation magnetic flux density Bs of said core layer and a magnetic pole layer and having outstanding soft magnetic characteristics, it becomes possible to manufacture the thin film magnetic head which could form said desired core layer and desired magnetic pole layer of a configuration, and was excellent in corrosion resistance with sufficient repeatability.
[0038] Moreover, the manufacture approach of the soft-magnetism film of this invention is characterized by to carry out plating formation of the soft-magnetism film which it is the approach of forming the FeNi system alloy containing S with electrolysis plating, and the plating bath used like electrolysis galvanizer is made to contain Fe ion, nickel ion, and S ion, dicarboxylic acid is further added during this plating bath, and the presentation ratio of S exceeds 0.116 mass %, and becomes 0.140 mass % and the following.
[0039] Like this invention, if dicarboxylic acid is added during a plating bath, Element S will become is easy to be incorporated in the soft magnetism film, and it will become possible to carry out specified quantity content of the presentation ratio of the element S in the inside of said soft magnetism film.
[0040] It is desirable for said dicarboxylic acid to be the sodium tartrate, and and to make the addition of said sodium tartrate into less than 100 mmol/L rather than 37 mmol/L to said whole plating bath, in this invention.
[0041] In this invention, when the sodium tartrate is chosen as dicarboxylic acid, repeatability can improve [plating formation] the FeNi system alloy which the presentation ratio of S exceeds 0.116 mass %, and becomes under 0.140 mass % by making the addition of said sodium tartrate into above-mentioned within the limits.

[0042] In addition, the sodium tartrate was made into 100 or less mmol/L because the corrosion resistance of that ****** of the film surface of a FeNi system alloy cannot become severe, and a predetermined magnetic pole configuration cannot be formed and a FeNi system alloy would fall, if more than this and the sodium tartrate were added. I understand by the experiment which it mentions later by making the addition of the sodium tartrate into 100 or less mmol/L that center line average-of-roughness-height Ra of a film surface is made to 200A or less.
[0043] Moreover, in this invention, said dicarboxylic acid is the sodium tartrate, and it is more desirable to make the addition of said sodium tartrate into 82 or less mmol/L to said whole plating bath at 62 or more mmol/L.
[0044] By adding the above-mentioned dicarboxylic acid sodium, more certainly than 0.116 mass %, and the element S contained in a FeNi system alloy is made into the presentation range smaller than 0.140 mass %. Moreover, the small FeNi system alloy of ****** of a film surface can be formed, and according to this invention, center line average-of-roughness-height Ra of said film surface can be held down to 80A or less.
[0045] Moreover, according to the addition of the above-mentioned dicarboxylic acid, the presentation ratio of said S is able to carry out plating formation of the soft magnetism film which becomes below 0.132 mass % above 0.125 mass %.
[0046] Moreover, it is desirable to mix saccharin sodium during a plating bath in this invention. S contained in this saccharin sodium (C6H4CONNaSO2) is considered to be incorporated by addition of dicarboxylic acid in a FeNi system alloy.
[0047] Moreover, it is desirable to carry out plating formation of said soft magnetism film in this invention with electrolysis plating which used pulse current.
[0048] In electrolysis plating using pulse current, ON/OFF of a current controlling element is repeated, for example, and the time amount which passes a current at the time of plating formation, and the blank time amount which does not pass a current are established. Thus, it is possible to carry out plating formation of the NiFe system alloy film little by little, to compare with electrolysis plating using the direct current currently generally used conventionally by establishing the time amount which does not pass a current, and to ease the bias of distribution of the current density at the time of plating formation. According to electrolysis plating by pulse current, adjustment of Fe content contained in the soft magnetism film compared with electrolysis plating by the direct current becomes easy, and many said Fe contents in the film can be incorporated.
[0049] Moreover, this invention is characterized by carrying out plating formation of said up core layer and/or the lower core layer with the soft magnetism film formed by the manufacture approach indicated above in the manufacture approach of the thin film magnetic head of having said lower core layer, the up core layer which counters through a magnetic gap, and the coil layer which guides a record field to both core layers at the lower core layer made from a magnetic material, and an opposed face with a record medium.
[0050] Moreover, it is desirable to carry out the bosselation of the lower magnetic pole layer by the opposed face with a record medium on said lower core layer, and to carry out plating formation of said lower magnetic pole layer with said soft magnetism film in this invention, at this time.
[0051] Moreover, this invention is located between a lower core layer and an up core layer, and said lower core layer and up core layer, and has the magnetic pole section by which the width method of the truck cross direction was regulated shorter than said lower core layer and an up core layer. The lower magnetic pole layer which follows a lower core layer in said magnetic pole section, the up magnetic pole layer which follows an up core layer, It forms in said lower magnetic pole layer and the gap layer located between said up magnetic pole layers. And or said magnetic pole section It forms in the gap layer located between the up magnetic pole layer which follows an up core layer, and said up magnetic pole layer and lower core layer, and is characterized by carrying out plating formation of said up magnetic pole layer and/or the lower magnetic pole layer with the soft magnetism film formed by the manufacture approach indicated above.
[0052] Moreover, it is desirable to form the up core layer which carries out plating formation of said up magnetic pole layer by said soft magnetism film, and is formed on said up magnetic pole layer in this invention by the soft magnetism film which has the saturation magnetic flux density Bs lower than said up magnetic pole layer.

[0053] Moreover, it is desirable to carry out plating formation of the magnetic layer which forms the part of said core layer which adjoins a magnetic gap at least by the magnetic layer more than two-layer, or forms said magnetic pole layer by the magnetic layer more than two-layer, and touches said magnetic gap among said magnetic layers in this invention with said soft magnetism film.
[0054] Moreover, it is desirable to form by the soft magnetism film which has the saturation magnetic flux density Bs lower than the magnetic layer which touches said magnetic gap layer in other magnetic layers except touching said magnetic gap layer in this invention.
[0055] As it was made the above, during a plating bath, into a FeNi system alloy, it becomes easy to incorporate Element S and has the high saturation magnetic flux density Bs, and it is low stress and the low coercive force Hc, and, according to the manufacture approach of the soft magnetism film in this invention, the soft magnetism film with still smaller ****** of a film surface can be formed with sufficient repeatability by adding dicarboxylic acid.
[0056] And it becomes possible to manufacture easily the thin film magnetic head which had the high saturation magnetic flux density Bs, are low stress and the low coercive force Hc, could form the core layer with still smaller ****** of a film surface, and the magnetic pole layer with sufficient repeatability, and was excellent in high recording density-ization carrying out plating formation of the soft magnetism film in this invention as the core layer and magnetic pole layer of the thin film magnetic head using this manufacture approach.
[0057]
[Embodiment of the Invention] The soft magnetism film of the gestalt of operation of this invention is a FeNi system alloy, and contains S other than Fe and nickel.
[0058] According to this invention, while having the high saturation magnetic flux density Bs, the low FeNi system alloy of stress and coercive force Hc can be formed. Furthermore, ****** of a film surface can be made small.
[0059] Fe is an important magnetic element, in order to mainly aim at improvement in saturation magnetic flux density Bs. Many amounts of Fe(s) can raise said saturation magnetic flux density Bs, so that there are.
[0060] At the former, although said amount of Fe(s) was about 55 mass % extent, by this invention, and said amount of Fe(s) is set up under 75 mass % from 55 mass %.
[0061] Saturation magnetic flux density Bs is made more than 1.6T by making [more] said amount of Fe(s) than 55 mass %. Moreover, with electrolysis plating using the pulse current mentioned later, the amount of Fe(s) can be easily adjusted to under 75 mass %.
[0062] Moreover, as for said presentation ratio of Fe, in this invention, it is desirable that it is more than 72 mass %. Saturation magnetic flux density Bs is made more than 1.8T by this.
[0063] Moreover, in this invention, said presentation ratio of Fe is within the limits below 80 mass % more preferably above 68 mass %. If said presentation ratio of Fe is carried out more than 68 mass %, said saturation magnetic flux density Bs will be made more than 1.8T. Moreover, in this invention, it becomes possible to raise said saturation magnetic flux density Bs even to more than 1.9T or about 2.0T depending on a presentation ratio.
[0064] However, if it is desirable that it is below 80 mass % as for said Fe presentation ratio and the amount of Fe(s) increases more than this, it is checked by the experiment which that stress becomes large and film peeling arises mentions later. Moreover, degradation of the soft magnetic characteristics accompanying increase of coercive force Hc also poses a problem by big and rough-ization of the diameter of crystal grain. Therefore, in this invention, said presentation ratio of Fe is set below to 80 mass %.
[0065] In this invention, it was a FeNi system alloy containing the above-mentioned amount of Fe (s), and the presentation ratio of Element S was set up as follows that the increase of stress and the increase of coercive force Hc which are regarded as questionable because the amount of Fe (s) increases should be improved, maintaining the high saturation magnetic flux density Bs.
[0066] By this invention, the presentation ratio of said S exceeds 0.116 mass % first, and it is desirable that it is under 0.140 mass %. According to the experimental result mentioned later, although the comparable amount of Fe(s) was included, it turned out that reduction of stress can be aimed at and coercive force Hc can be made small compared with the soft magnetism film with

few S presentation ratios than this invention. According to this invention, stress (stress) can be held down to 200 or less MPas. Moreover, the coercive force Hc of the direction of an easy axis can be suppressed for the coercive force Hc of the direction of a hard axis to the about 400 (A/m) following the about 600 (A/m) following.
[0067] Moreover, as for the presentation ratio of said S, in this invention, it is desirable that it is more than 0.126 mass %. Reduction of stress and reduction of coercive force Hc can be more appropriately aimed at by this. Specifically, the coercive force Hc of the direction of an easy axis can be suppressed [said stress] in general for the coercive force Hc of the direction of a hard axis below to 270 (A/m) below 470 (A/m) below 160 (A/m).
[0068] In this invention, it is setting the presentation ratio of said S below to 0.132 mass % more preferably above 0.125 mass %. Reduction of stress and reduction of coercive force Hc can be more appropriately aimed at by this. Specifically, the coercive force Hc of the direction of an easy axis can be suppressed [said stress] in general for the coercive force Hc of the direction of a hard axis below to 270 (A/m) below 470 (A/m) below 160 (A/m).
[0069] By the way, in order to make Element S contain in above-mentioned presentation Hinai, it can attain by adding dicarboxylic acid during a plating bath so that it may mention later. If the addition of said dicarboxylic acid is made [many], the experiment which that the presentation ratio of Element S becomes large mentions later shows.
[0070] However, when the addition of said dicarboxylic acid was made [many] too much, it turned out that ****** of a film surface becomes severe. The thing small as much as possible of ****** of a film surface is desirable. Since the layer formed on it will not be formed in a suitable configuration in response to the effect of ****** if ****** of said FeNi system alloy film is severe when using the above-mentioned FeNi system alloy especially as the thin film magnetic head, we cannot form the cascade screen which has a predetermined configuration and a predetermined property, and are anxious about the problem of a corrosion resistance fall.
[0071] Therefore, as for ****** of a film surface, it is desirable to make it as small as possible. When the sodium tartrate is used as dicarboxylic acid so that it may mention later, to the whole plating bath, rather than 37 mmol/L, there are many additions of said sodium tartrate, and they are set as less than 100 mmol/L. By this, the presentation ratio of the element S contained in said FeNi system alloy becomes under 0.140 mass %, and can hold down center line average-of-roughness-height Ra of a film surface to 200A or less at this time.
[0072] More preferably, it is setting the addition of said sodium tartrate as 82 or less mmol/L by 62 or more mmol/L to the whole plating bath, and it is possible to be able to make the content of Element S and smaller [than 0.116 mass %] than 0.140 mass %, and to hold down center line average-of-roughness-height Ra of a film surface to 80A or less more certainly, by this.
[0073] Moreover, the presentation ratio of the element S contained in said FeNi system alloy as it is the addition of the above-mentioned sodium tartrate is made to presentation within the limits below 0.132 mass % above 0.125 mass %. Moreover, it is possible to hold down center line average-of-roughness-height Ra of a film surface to 80A or less.
[0074] However, it is thought that center line average-of-roughness-height Ra of a film surface receives effect not only in the amount of S but in the amount of Fe(s), and 200A or less is preferably considered [which are the range under of 75 mass %, and carrying out to below 80 mass %, and described above more preferably more / and / said amounts of Fe(s) than 55 mass % above 68 mass %] that center line average-of-roughness-height Ra 80A or less is securable by this invention.
[0075] In addition, containing Element C besides Element S is checked by the above-mentioned FeNi system alloy.
[0076] An example of the FeNi system alloy film in this invention is indicated below. Thickness is about 2 micrometers, for the presentation ratio of Fe, about 72 mass % and the presentation ratio of nickel is [the presentation ratio of about 27 mass % and S] 0.125 to 0.132 mass %s, and the remainder is C. In addition, these presentation ratio is as a result of [by EPMA] a component analysis.
[0077] While the coercive force Hc and stress of this soft magnetism film decline with the increment in the presentation ratio of S and coercive force Hc (the direction of a hard axis) is 480

or less A/m in general, stress (measurement by the camber of 4inchSi substrate) is 160 or less MPas in general. Moreover, an anisotropy field goes up by the increment in the presentation ratio of S, and is 210 or more A/m.
[0078] Moreover, this soft magnetism film has the presentation ratio of Fe as high as 72 mass %, in order to consider as the high saturation magnetic flux density Bs. Saturation magnetic flux density Bs is not influenced [big] by the presentation ratio of S, but is held at about 1.9 T.
[0079] Moreover, the specific resistance of this soft magnetism film is not influenced [big] by the presentation ratio of S, but is held at about 32micro ohm-cm.
[0080] The FeNi system alloy in this invention explained in full detail above is used as the core layer or magnetic pole layer of the thin film magnetic head explained below.
[0081] The thin film magnetic head carried in a hard magnetic disk drive etc. It is the compound-die thin film magnetic head which consisted of the head section h1 for playback, and the head section h2 (inductive head) for record as shown in drawing 1 . For example, the head section h1 for playback The lower shielding layer 2 which is formed in end side 1a of a slider 1 through the substrate layers 15, such as an alumina, for example, consists of a FeNi system alloy, Consisted of an alumina etc. and formed the lower shielding layer 2 on the wrap lower gap layer 3 and the lower gap layer 3. The magneto-resistive effect component 4 using an anisotropy magneto-resistive effect (the AMR effectiveness), giant magneto-resistance (the GMR effectiveness), or a tunnel mold magneto-resistive effect (the TMR effectiveness), The magneto-resistive effect component 4 and the electrode layer 5 consist of a wrap up gap layer 6 and an up shielding layer 7 formed on the up gap layer 6 by becoming the electrode layer 5 electrically connected to the magneto-resistive effect component 4 from an alumina etc.
[0082] The head section h2 for record on the head section h1 for playback The gap layer 8 by which it was used also [layer / 7 / of the head section h1 for playback / up shielding], and the lower core layer 7 is the soft magnetism film which consists of a FeNi system alloy, consisted of an alumina or a non-magnetic material of SiO2 grade, and was formed on the lower core layer 7, It consists of right electric conduction material, such as Cu, and has the coil layer 9 by which pattern formation was carried out on the gap layer 8, and the up core layer 10 formed through the insulating layers 11, such as a resist applied on the coil layer 9, and the up core layer 10 is soft magnetism film which consists of a FeNi system alloy like the lower core layer 7. End face section 10a of the up core layer 10 is in the condition of having connected with the lower core layer used also [layer / 7 / up shielding] magnetically, and spacing to which the lower core layer 7 and the up core layer 10 pinch the gap layer 8 to the magnetic-disk opposed face 1b side serves as the write-in gap G.
[0083] The protective coat 16 which consists of carbon is formed in the magnetic-disk opposed face 1b side of such the thin film magnetic head, and the up core layer 10 and the lower core layer 7 are covered with the protective coat 16.
[0084] Next, the drive of the thin film magnetic head of this invention is explained. At the time of the drive of the thin film magnetic head, a record current is impressed to the coil layer 9, and a record field is guided to the up core layer 10 and the lower core layer 7 according to a record current. Since a record field pierces through the up core layer 10 and the lower core layer 7 in the direction of a hard axis at this time, the up core layer 10 and the lower core layer 7 have the magnetic properties in the direction of a hard axis of the soft magnetism film.
[0085] The record field guided to the up core layer 10 and the lower core layer 7 leaks between the write-in gaps G, and turns into a field, and magnetic recording is given to a record medium by the leak field.
[0086] Since such the thin film magnetic head has the saturation magnetic flux density Bs with high up core layer 10 and lower core layer 7, it can respond to high recording density-ization. Moreover, in order to correspond to a high record frequency, the specific resistance of the up core layer 10 and the lower core layer 7 is high, and although it is required to suppress eddy current loss, the specific resistance of the up core layer 10 and the lower core layer 7 cannot be different from the former, and can hold high record frequency characteristics.
[0087] Said up core layer 10 and the lower core layer 7 are formed by the soft magnetism film of the already explained FeNi system alloy.

[0088] according to this invention -- said FeNi system alloy -- 0.116 mass % -- exceeding -- and under 0.140 mass % -- or more than 0.125 mass % -- the element S below 0.132 mass % -- containing -- moreover, 55 mass % -- exceeding -- and under 75 mass % -- Fe below 80 mass % is preferably included above 68 mass %.
[0089] And according to the above-mentioned FeNi system alloy, saturation magnetic flux density Bs is preferably made more than 1.8T more than 1.6T, and the equivalent amount of Fe(s) is included, but S presentation ratio is small in stress as compared with the low soft magnetism film compared with this invention, and, moreover, can make coercive force Hc small. Coercive force Hc affects soft magnetic characteristics, such as saturation magnetic flux density Bs and an anisotropy field, and it can make said soft magnetic characteristics good, so that it makes coercive force Hc small. ****** of a film surface is also still smaller.
[0090] Since the above-mentioned FeNi system alloy has the high saturation magnetic flux density Bs and is excellent in other soft magnetic characteristics, it is using said FeNi system alloy for the lower core layer 7 and the up core layer 10, and it becomes possible to centralize magnetic flux near the gap of said core layer, and to raise recording density, and it can manufacture the thin film magnetic head which can respond to future high recording density-ization.
[0091] And the stress of said core layer is also low, and it becomes possible to stick said core layer with the layer of the upper and lower sides appropriately, and to form it, without film peeling arising in said core layer at the time of formation of said core layer, since ****** of a film surface is also still smaller.
[0092] Moreover, it becomes possible to form gap length [who it is easy to form the very thin gap layer 8 of the thickness formed on it when said FeNi system alloy is used for the lower core layer 7, for example, while excelling in corrosion resistance, since ****** of a film surface was also small by predetermined thickness, and is determined spacing between said lower core layer 7 and the up core layer 10] G with repeatability sufficient by predetermined die length.
[0093] In addition, in the above-mentioned explanation, although the thin film magnetic head of this invention was explained as the compound-die thin film magnetic head, the thin film magnetic head only for records of only the head section for record is sufficient. Moreover, although both the up core layer 10 and the lower core layer 7 were used as the soft magnetism film of this invention with the gestalt of the above-mentioned implementation, one of the up core layer 10 and the lower core layers 7 should just be the soft magnetism film of this invention.
[0094] In this invention, the soft magnetism film of the FeNi system alloy in this invention can be used also for the thin film magnetic heads other than the structure shown in drawing 1 . The structure of other thin film magnetic heads in this invention is explained below.
[0095] It is partial drawing of longitudinal section where drawing 2 cut the thin film magnetic head which shows the partial front view of other thin film magnetic heads in this invention, and drawing 3 to drawing 2 from the alternate long and short dash line, and looked at it from the arrow head.
[0096] The structure of the head section h1 for playback is the same as drawing 1 . Moreover, with the operation gestalt shown in drawing 2 and drawing 3 , said up shielding layer 7 is made to serve a double purpose also as a lower core layer of the head section h2 for record like drawing 1 , Gd arrangement layer 17 is formed on said lower core layer 7, and a gap depth (Gd) is regulated with the die-length dimension from an opposed face with a record medium to the point of said Gd arrangement layer 17. Said Gd arrangement layer 17 is formed for example, by the organic insulating material.
[0097] Moreover, top-face 7a of said lower core layer 7 is formed in the inclined plane which inclines in the direction of an inferior surface of tongue as are shown in drawing 2 and it is separated from the end face of the magnetic pole section 18 crosswise [truck] (the direction of illustration X), and it is possible for this to control generating of side fringing.
[0098] Moreover, as shown in drawing 3 , it applies on said Gd arrangement layer 17 from an opposed face with a record medium, and the magnetic pole section 18 is formed.
[0099] As for said magnetic pole section 18, the laminating of the lower magnetic pole layer 19, the nonmagnetic gap layer 20, and the up magnetic pole layer 21 is carried out from the bottom.
[0100] Direct plating formation of said lower magnetic pole layer 19 is carried out on the lower core layer 7. Moreover, as for the gap layer 20 formed on said lower magnetic pole layer 19, it is

desirable to be formed with the non-magnetic metal ingredient in which plating formation is possible. Specifically, it is desirable to be chosen from one sort or two sorts or more in NiP, NiPd, NiW, NiMo, and Au, Pt, Rh, Pd, Ru and Cr.
[0101] In addition, NiP is used for said gap layer 20 as a concrete operation gestalt in this invention. It is because said gap layer 20 changes into a nonmagnetic condition appropriately by forming said gap layer 20 by NiP.
[0102] The up magnetic pole layer 21 furthermore formed on said gap layer 20 is magnetically connected with the up core layer 22 formed on it.
[0103] If the gap layer 20 is formed as mentioned above with the non-magnetic metal ingredient in which plating formation is possible, it is possible to carry out continuation plating formation of the lower magnetic pole layer 19, the gap layer 20, and the up magnetic pole layer 21.
[0104] In addition, said magnetic pole section 18 may consist of two-layer [of the gap layer 20 and the up magnetic pole layer 21].
[0105] As shown in drawing 2 , the width method [in / in said magnetic pole section 18 / the truck cross direction (the direction of illustration X)] is formed with the width of recording track Tw.
[0106] As shown in drawing 2 and drawing 3 , the insulating layer 23 which consists of an inorganic insulating material is formed the both sides and behind [height direction] (the direction of illustration Y) said magnetic pole section 18. [of the truck cross direction (the direction of illustration X)] The top face of said insulating layer 23 is made into the same flat surface as the top face of said magnetic pole section 18.
[0107] As shown in drawing 3 , on said insulating layer 23, pattern formation of the coil layer 24 is carried out spirally. Moreover, said coil layer 24 top is covered with the insulating layer 25 made from an organic insulating material. In addition, said coil layer 24 may be the configuration by which the laminating was carried out more than two-layer on both sides of the insulating layer.
[0108] As shown in drawing 3 , it applies on an insulating layer 25 from on the magnetic pole section 18, and pattern formation of the up core layer 22 is carried out for example, by frame plating. As shown in drawing 2 , a width method [in / in point 22a of said up core layer 22 / the truck cross direction in an opposed face with a record medium] is formed by T1, and this width method T1 is formed more greatly than the width of recording track Tw.
[0109] Moreover, as shown in drawing 3 , direct continuation of the end face section 22b of said up core layer 22 is carried out on the connection layer 26 made from the magnetic material formed on the lower core layer 7 (back gap layer).
[0110] In this invention, said up magnetic pole layer 21 and/or the lower magnetic pole layer 19 are formed with the FeNi system alloy in this invention.
[0111] this invention -- said FeNi system alloy -- 0.116 mass % -- exceeding -- and under 0.140 mass % -- or more than 0.125 mass % -- the element S below 0.132 mass % -- containing -- moreover, 55 mass % -- exceeding -- and under 75 mass % -- Fe below 80 mass % is preferably included above 68 mass %.
[0112] And according to the above-mentioned FeNi system alloy, saturation magnetic flux density Bs is preferably made more than 1.8T more than 1.6T, and the equivalent amount of Fe(s) is included, but S presentation ratio is small in stress as compared with the low soft magnetism film compared with this invention, and, moreover, can make coercive force Hc small. Coercive force Hc affects soft magnetic characteristics, such as saturation magnetic flux density Bs and an anisotropy field, and it can make said soft magnetic characteristics good, so that it makes coercive force Hc small. ****** of a film surface is also still smaller.
[0113] Therefore, by using said FeNi system alloy for the magnetic pole layers 19 and 21, the thin film magnetic head excellent in high recording density-ization should be formed with sufficient repeatability, said magnetic pole layers 19 and 21 formed in very narrow space since ****** is also low stress small should be formed in the predetermined magnetic pole configuration, and it should excel in corrosion resistance.
[0114] The partial front view showing the structure of the thin film magnetic head of other operation gestalten [in / in drawing 4 / this invention] and drawing 5 are drawings of longitudinal section which cut the thin film magnetic head from the alternate long and short dash line shown in

drawing 4 , and were seen from the arrow head.
[0115] With this operation gestalt, the structure of the head section h1 for playback is the same as drawing 1 thru/or drawing 3 .
[0116] As shown in drawing 4 , on the lower core layer 7, the insulating layer 31 formed by the inorganic insulating material is formed. Width-of-recording-track formation slot 31a formed in the height direction (direction of illustration Y) back with the predetermined die-length dimension from the opposed face with a record medium is formed in said insulating layer 31. Said width-of-recording-track formation slot 31a is formed with the width of recording track Tw in the opposed face with a record medium (refer to drawing 4).
[0117] The magnetic pole section 30 to which the laminating of the lower magnetic pole layer 32, the nonmagnetic gap layer 33, and the up magnetic pole layer 34 was carried out from the bottom is formed in said width-of-recording-track formation slot 31a.
[0118] Direct plating formation of said lower magnetic pole layer 32 is carried out on the lower core layer 7. Moreover, as for the gap layer 33 formed on said lower magnetic pole layer 32, it is desirable to be formed with the non-magnetic metal ingredient in which plating formation is possible. Specifically, it is desirable to be chosen from one sort or two sorts or more in NiP, NiPd, NiW, NiMo, and Au, Pt, Rh, Pd, Ru and Cr.
[0119] In addition, NiP is used for said gap layer 33 as a concrete operation gestalt in this invention. It is because said gap layer 33 changes into a nonmagnetic condition appropriately by forming said gap layer 33 by NiP.
[0120] In addition, said magnetic pole section 30 may consist of two-layer [of the gap layer 33 and the up magnetic pole layer 34].
[0121] On said gap layer 33, it applies on an insulating layer 31 from the location which separated only the gap depth (Gd) from the opposed face with a record medium, and Gd arrangement layer 37 is formed. Said Gd arrangement layer 37 is formed for example, by the organic insulating material.
[0122] The up magnetic pole layer 34 furthermore formed on said gap layer 33 is magnetically connected with the up core layer 40 formed on it.
[0123] If the gap layer 33 is formed as mentioned above with the non-magnetic metal ingredient in which plating formation is possible, it is possible to carry out continuation plating formation of the lower magnetic pole layer 32, the gap layer 33, and the up magnetic pole layer 34.
[0124] As shown in drawing 5 , on said insulating layer 31, pattern formation of the coil layer 38 is carried out spirally. Said coil layer 38 is covered with the insulating layer 39 formed by the organic insulating material etc.
[0125] As shown in drawing 4 , the inclined planes 31c and 31c where a width method spreads gradually according to the direction which is missing from top-face 31b of said insulating layer 31 from the top face of said up magnetic pole layer 34, and separates from the lower core layer 7 are formed in the both-sides end face in the truck cross direction (the direction of illustration X) of width-of-recording-track formation slot 31a.
[0126] And as shown in drawing 4 , point 40a of the up core layer 40 is formed in the direction which applies on said inclined plane 31c and 31c from said up magnetic pole layer 34 top face, and separates from the lower core layer 7.
[0127] As shown in drawing 5 , it is formed on an insulating layer 39, up applying [said / 40] it in the height direction (the direction of illustration Y) from an opposed face with a record medium, and end face section 40b of said up core layer 40 is directly formed on the lower core layer 7.
[0128] In the operation gestalt shown in drawing 4 and drawing 5 , the lower magnetic pole layer 32 and/or the up magnetic pole layer 34 are formed by the soft magnetism film of the FeNi system alloy in this invention.
[0129] this invention -- said FeNi system alloy -- 0.116 mass % -- exceeding -- and under 0.140 mass % -- or more than 0.125 mass % -- the element S below 0.132 mass % -- containing -- moreover, 55 mass % -- exceeding -- and under 75 mass % -- Fe below 80 mass % is preferably included above 68 mass %.
[0130] And according to the above-mentioned FeNi system alloy, saturation magnetic flux density Bs is preferably made more than 1.8T more than 1.6T, and the equivalent amount of Fe(s) is

included, but S presentation ratio is small in stress as compared with the low soft magnetism film compared with this invention, and, moreover, can make coercive force Hc small. Coercive force Hc affects soft magnetic characteristics, such as saturation magnetic flux density Bs and an anisotropy field, and it can make said soft magnetic characteristics good, so that it makes coercive force Hc small. ****** of a film surface is also still smaller.

[0131] Therefore, by using said FeNi system alloy for the magnetic pole layers 32 and 34, the thin film magnetic head excellent in high recording density-ization should be formed with sufficient repeatability, said magnetic pole layers 19 and 21 formed in very narrow space since ****** is also low stress small should be formed in the predetermined magnetic pole configuration, and it should excel in corrosion resistance.

[0132] Moreover, the laminating of the magnetic layer more than two-layer may be carried out, and said lower magnetic pole layers 19 and 32 and/or the up magnetic pole layers 21 and 34 which are shown in drawing 2 thru/or drawing 5 may consist of this inventions. In this configuration, it is desirable to form the magnetic layer of the side which touches the gap layers 20 and 33 with the FeNi system alloy in this invention. Moreover, it is desirable to form with the FeNi system alloy which described above the magnetic layer of the side which touches said especially gap layers 20 and 33 and which that including Fe below 80 mass % are under 0.140 mass %s above 68 mass %, or contains S below 0.132 mass % above 0.125 mass %. [than 0.116 mass %] [more / and] While being able to centralize magnetic flux more near the gap and being able to manufacture the thin film magnetic head which can respond to future high recording density-ization by this, it is possible for film peeling etc. not to occur but to form the magnetic pole layer of a predetermined configuration with sufficient repeatability.

[0133] Moreover, although other magnetic layers other than the magnetic layer which touches said gap layers 20 and 33 may be formed with the magnetic material of what kind of the quality of the material and a presentation ratio, it is more desirable than the magnetic layer of the side which touches said gap layers 20 and 33 that saturation magnetic flux density Bs becomes small. It becomes possible to draw a record field suitable for the magnetic layer of the side which touches the gap layers 20 and 33 from a magnetic layer besides the above by this, and to attain high recording density-ization.

[0134] Moreover, although the high thing of the saturation magnetic flux density Bs of the lower magnetic pole layers 19 and 32 is desirable, if flux reversal of the leak field between a lower magnetic pole layer and an up magnetic pole layer is made easy to carry out by making it lower than the saturation magnetic flux density Bs of the up magnetic pole layers 21 and 34, the write-in consistency of the signal to a record medium can be made high more.

[0135] Drawing 6 is drawing of longitudinal section of the thin film magnetic head of other operation gestalten in this invention. Although a strong resemblance to the structure of the thin film magnetic head of drawing 1 is born, a difference is that the laminating of the up core layer 10 is carried out, and it consists of two-layer magnetic layers.

[0136] Said up core layer 10 consists of the upper layers 48 by which the laminating was carried out to the high Bs layer 47 which has the high saturation magnetic flux density Bs on it.

[0137] Said quantity Bs layer 47 and/or the lower core layer 7 are formed with the FeNi system alloy in this invention.

[0138] this invention -- said FeNi system alloy -- 0.116 mass % -- exceeding -- and under 0.140 mass % -- or more than 0.125 mass % -- the element S below 0.132 mass % -- containing -- moreover, 55 mass % -- exceeding -- and under 75 mass % -- Fe below 80 mass % is preferably included above 68 mass %.

[0139] And according to the above-mentioned FeNi system alloy, saturation magnetic flux density Bs is preferably made more than 1.8T more than 1.6T, and the equivalent amount of Fe(s) is included, but S presentation ratio is small in stress as compared with the low soft magnetism film compared with this invention, and, moreover, can make coercive force Hc small. Coercive force Hc affects soft magnetic characteristics, such as saturation magnetic flux density Bs and an anisotropy field, and it can make said soft magnetic characteristics good, so that it makes coercive force Hc small. ****** of a film surface is also still smaller.

[0140] While being able to improve soft magnetic characteristics, such as saturation magnetic flux

density Bs, being able to centralize magnetic flux near the gap and being able to raise recording density by using the FeNi system alloy in this this invention as said quantity Bs layer 47 and/or a lower core layer 7, film peeling etc. does not occur but the core layer of a predetermined configuration can be easily formed with sufficient repeatability.
[0141] Although saturation magnetic flux density Bs is small compared with the high Bs layer 47, as for the upper layer 48 which constitutes said up core layer 10, specific resistance is made higher than said quantity Bs layer 47. Said upper layer 48 is formed for example, with nickel80Fe20 alloy.
[0142] by this, said quantity Bs layer 47 has the saturation magnetic flux density Bs higher than said upper layer 48, and concentrates magnetic flux near the gap -- making -- record -- it becomes possible to raise resolution.
[0143] Moreover, by the high upper layer 48 of specific resistance having been formed in the up core layer 46, loss by the eddy current generated when a record frequency rises can be reduced, and the thin film magnetic head which can respond to future high record frequency-ization can be manufactured.
[0144] Moreover, as this invention shows to drawing 6 , it is desirable that the high Bs layer 47 is formed in the gap layer 41 and lower layer side which counters. Moreover, said quantity Bs layer 47 may be formed only in point 46a of the up core layer 46 which touches directly on the gap layer 41.
[0145] Moreover, the lower core layer 7 may also consist of two-layer [of a high Bs layer and a high specific resistance layer]. In this configuration, the laminating of the high Bs layer is carried out on a high specific resistance layer, and said quantity Bs layer counters with the up core layer 10 through the gap layer 41.
[0146] Moreover, although the up core layer 10 has a two-layer laminated structure with the operation gestalt shown in drawing 6 , you may be three or more layers. As for the high Bs layer 47, in this configuration, it is desirable to be formed in the side which touches the magnetic gap layer 41.
[0147] Drawing 7 is drawing of longitudinal section of the thin film magnetic head of other operation gestalten in this invention. With the operation gestalt of drawing 7 , the configuration of the head section h1 for playback is the same as drawing 1 . As shown in drawing 7 , the bosselation of the lower magnetic pole layer 50 is carried out from the opposed face with a record medium on the lower core layer 7. The insulating layer 51 is formed behind [height direction] said lower magnetic pole layer 50 (the direction of illustration Y). The top face of said insulating layer 51 serves as a concave configuration, and coil forming face 51a is formed.
[0148] It applies on said insulating layer 51 from on said lower magnetic pole layer 50, and the gap layer 52 is formed. Furthermore on coil forming face 51a of said insulating layer 51, the coil layer 53 is formed through the gap layer 52. Said coil layer 53 top is covered with the insulating layer 54 made from an organic insulation.
[0149] As shown in drawing 7 , pattern formation is carried out by frame plating, up applying [55] it on an insulating layer 54 from on said gap layer 52.
[0150] On said gap layer 52, point 55a of said up core layer 55 counters with the lower magnetic pole layer 50, and is formed. End face section 55b of said up core layer 55 was formed on the lower core layer 7, is raised, and is magnetically connected to said lower core layer 7 through a layer 56.
[0151] In this operation gestalt, the up core layer 55 and/or the lower magnetic pole layer 50 are formed with the FeNi system alloy in this invention.
[0152] this invention -- said FeNi system alloy -- 0.116 mass % -- exceeding -- and under 0.140 mass % -- or more than 0.125 mass % -- the element S below 0.132 mass % -- containing -- moreover, 55 mass % -- exceeding -- and under 75 mass % -- Fe below 80 mass % is preferably included above 68 mass %.
[0153] And according to the above-mentioned FeNi system alloy, saturation magnetic flux density Bs is preferably made more than 1.8T more than 1.6T, and the equivalent amount of Fe(s) is included, but S presentation ratio is small in stress as compared with the low soft magnetism film compared with this invention, and, moreover, can make coercive force Hc small. Coercive force Hc

affects soft magnetic characteristics, such as saturation magnetic flux density Bs and an anisotropy field, and it can make said soft magnetic characteristics good, so that it makes coercive force Hc small. ****** of a film surface is also still smaller.
[0154] The thin film magnetic head which can respond can be manufactured with sufficient repeatability suitable for a raise in recording density which could form said magnetic pole layer and core layer as film which does not have film peeling etc. and was excellent in the corrosion resistance of a predetermined configuration, and was excellent in soft magnetic characteristics, such as saturation magnetic flux density Bs, using the above-mentioned FeNi alloy for the lower magnetic pole layer 50 and/or the up core layer 55.
[0155] Moreover, although the whole may be formed with said FeNi system alloy, as for the up core layer 55, the side which said up core layer 55 is the laminated structure of the magnetic layer more than two-layer, and counters with the gap layer 52 like drawing 6 may be formed by said FeNi system alloy film as a high Bs layer. Moreover, in this case, it is desirable that only point 55a of said up core layer 55 is formed by the laminated structure of the magnetic layer more than two-layer, and the high Bs layer is formed in contact with said gap layer 52 top, considering the point which is made to concentrate magnetic flux near the gap and raises recording density.
[0156] In addition, as for the FeNi system alloy film, in each operation gestalt shown in drawing 1 thru/or drawing 7 by this invention, it is desirable that plating formation is carried out. In this invention, plating formation of said FeNi system alloy can be carried out with electrolysis plating which used pulse current. Moreover, it can form by the thickness of arbitration by carrying out plating formation of said FeNi system alloy, and it becomes possible forming by thick thickness rather than forming by the spatter.
[0157] Moreover, in each operation gestalt, although the layer of a sign 7 is a lower core layer and the combination layer of an up shielding layer, said lower core layer and the up shielding layer may be formed separately. An insulating layer is made to intervene between said lower core layer and an up shielding layer in this case.
[0158] Next, the general manufacture approach of the thin film magnetic head shown in drawing 1 thru/or drawing 7 is explained below.
[0159] The thin film magnetic head shown in drawing 1 forms the gap layer 8 on the lower core layer 7 first, and carries out pattern formation of the coil layer 9 on said gap layer 8. After forming an insulating layer 11 on said coil layer 9, it applies on said insulating layer 11 from the gap layer 8, and pattern formation of the up core layer 10 is carried out with frame plating.
[0160] The thin film magnetic head shown in drawing 2 and drawing 3 forms the magnetic pole section 18 which consists in the height direction of the lower magnetic pole layer 19, the nonmagnetic gap layer 20, and the up magnetic pole layer 21 by continuation plating from an opposed face with a record medium using a resist, after forming Gd arrangement layer 17 on the lower core layer 7. Next, after forming an insulating layer 23 behind [height direction] said magnetic pole section 18, flattening of the top face of said magnetic pole section 18 and the top face of said insulating layer 23 is carried out to the same flat surface using a CMP technique. After carrying out pattern formation of the coil layer 24 spirally on said insulating layer 23, an insulating layer 25 is formed on said coil layer 24. And it applies on an insulating layer 25 from on said magnetic pole section 18, and the up core layer 22 is formed for example, with frame plating.
[0161] The thin film magnetic head shown in drawing 4 and drawing 5 forms width-of-recording-track formation slot 31a towards the height direction back using a resist from an opposed face with the record medium of said insulating layer 31, after forming an insulating layer 31 on the lower core layer 7. Furthermore, the inclined planes 31c and 31c shown in drawing 4 are formed in said width-of-recording-track formation slot 31a.
[0162] In said width-of-recording-track formation slot 31a, the lower magnetic pole layer 32 and the nonmagnetic gap layer 33 are formed. After forming Gd arrangement layer 37 on an insulating layer 31 from on said gap layer 33, plating formation of the up magnetic pole layer 34 is carried out on said gap layer 33. Next, after carrying out pattern formation of the coil layer 38 spirally on said insulating layer 31, an insulating layer 39 is formed on said coil layer 38. And it applies on an insulating layer 39 from on said up magnetic pole layer 34, and the up core layer 40 is formed for example, with frame plating.

[0163] After the thin film magnetic head shown in drawing 6 forms the gap layer 41 on the lower core layer 7 first and forms an insulating layer 43 further, it carries out pattern formation of the coil layer 44 on said insulating layer 43. After forming an insulating layer 45 on said coil layer 44, pattern formation of the up core layer 10 which applies on said insulating layer 45 from the gap layer 41, and consists of a high Bs layer 47 and the upper layer 48 is carried out with frame plating.
[0164] First, on the lower core layer 7, a resist is used for the thin film magnetic head shown in drawing 7 , it forms the lower magnetic pole layer 50, and forms an insulating layer 51 behind [height direction] said lower magnetic pole layer 50 further. Once flattening of the top face of said lower magnetic pole layer 50 and said insulating layer 51 is carried out by the CMP technique, it forms coil forming face 51a used as a concave configuration in the top face of said insulating layer 51. Next, after forming the gap layer 52 on said insulating layer 51 from on said lower magnetic pole layer 50, pattern formation of the coil layer 53 is spirally carried out on said gap layer 52, and an insulating layer 54 is further formed on said coil layer 53. And it applies on an insulating layer 54 from on said gap layer 52, and pattern formation of the up core layer 55 is carried out for example, with frame plating.
[0165] Next, the manufacture approach of the FeNi system alloy of this invention is explained. This invention forms the FeNi system alloy containing S with electrolysis plating. Compared with spatter vacuum deposition, as for electrolysis plating, a membrane formation rate can shorten production time early.
[0166] The plating bath used like said electrolysis galvanizer is made to contain Fe ion, nickel ion, and S ion in this invention. Specifically, the saccharin Na which is NiCl2 6 hydrate, NiSO4 6 hydrate, FeSO4 6 hydrate, NaOH, a boric acid, and a stress buffer, and the lauryl sulfuric acid Na of a surfactant are put in during the plating bath. S ion can be made to contain during a plating bath by putting in saccharin sodium (C6H4CONNaSO2).
[0167] Furthermore by this invention, dicarboxylic acid is added during said plating bath. As dicarboxylic acid, a tartaric acid [HOOC(C2H4O2) COOH], the sodium tartrate [HOOC (C2H2O2Na2) COOH], a potassium sodium tartrate [HOOC(C2H2O2NaK) COOH], oxalic acid (HOOCCOOH), a succinic acid [HOOC(CH2)2COOH], a malonic acid [HOOC(CH2) COOH], a maleic acid (HOOCHC=CHCOOH), etc. can be shown.
[0168] Although there is another citric acid etc. as dicarboxylic acid, molecular weight is large (molecular weight is 192), and if this has the too large molecular weight of dicarboxylic acid, it will check a plating rate, and is considered that it cannot control ****** of a film surface appropriately.
[0169] Therefore, it is desirable to choose dicarboxylic acid with a tartaric acid, equivalence, or molecular weight smaller than it, and to add during a plating bath.
[0170] And if said dicarboxylic acid is added during a plating bath, S ion contained during the plating bath will become that it is easy to be incorporated in the plating film, and it will become possible to make the element S of optimum dose contain in a FeNi system alloy.
[0171] According to this invention, 0.116 mass % can be exceeded in a FeNi system alloy, and the element S which becomes under 0.140 mass % can be made to contain by adjusting the addition of dicarboxylic acid appropriately.
[0172] It is desirable to choose the sodium tartrate as said dicarboxylic acid, and to more specifically than 37 mmol/L make the addition of said sodium tartrate into less than 100 mmol/L to said whole plating bath, at this time. By this, rather than 0.116 mass %, and it is presentation within the limits which becomes under 0.140 mass %, and the element S in said FeNi system alloy can be adjusted appropriately. Moreover, if having made said sodium tartrate into less than 100 mmol/L puts in more than this and the sodium tartrate, ****** of a film surface will become severe and center line average-of-roughness-height Ra of said film surface will specifically exceed 200A. Therefore, in this invention, said sodium tartrate is set as less than 100 mmol/L.
[0173] Moreover, in this invention, the sodium tartrate is chosen as said dicarboxylic acid, and it is more desirable at this time to make the addition of said sodium tartrate into 62 or more mmol/L 82 or less mmol/L to said whole plating bath. Center line average-of-roughness-height Ra of a film surface can be held down to 80A or less by this.

[0174] Moreover, if it is the addition of the above-mentioned sodium tartrate, more certainly than 0.116 mass %, and the presentation ratio of the element S in the FeNi system alloy by which plating formation was carried out can be made under into 0.140 mass %. Moreover, according to the experiment mentioned later, the presentation ratio of the element S contained in a FeNi system alloy can also be set below to 0.132 mass % above 0.125 mass %. The fall of stress and the fall of coercive force can be more effectively aimed at as it is this presentation within the limits.
[0175] Next, in this invention, although it is the presentation ratio of Fe of a FeNi system alloy, it is, and it being desirable than 55 mass % carrying out to under 75 mass %, and making said presentation ratio of Fe below into 80 mass % more preferably in this invention, above 68 mass %.
[0176] In order to make the amount of Fe(s) described above in the FeNi system alloy contain, it is desirable to use not electrolysis plating using a direct current but electrolysis plating using pulse current. In electrolysis plating using pulse current, ON/OFF of a current controlling element is repeated, for example, and the time amount which passes a current at the time of plating formation, and the blank time amount which does not pass a current are established. Thus, it is possible to carry out plating formation little by little, to compare the NiFe system alloy film with electrolysis plating using a direct current by establishing the time amount which does not pass a current, and to ease the bias of distribution of the current density at the time of plating formation. According to electrolysis plating by pulse current, adjustment of Fe content contained in the soft magnetism film compared with electrolysis plating by the direct current becomes easy, and many said Fe contents in the film can be incorporated.
[0177] Moreover, in order to set the amount of Fe(s) as presentation within the limits below 80 mass % in this invention above 68 mass %, it is desirable to reduce nickel ion concentration under plating bath conventionally further using electrolysis plating using the above-mentioned pulse current. For example, although nickel ion concentration under plating bath was 40 g/l extent in the former, nickel ion concentration is set as low concentration rather than this in this invention. Thereby, at the time of membrane formation, it becomes possible to be able to reduce nickel ion of the plating liquid which touches on a cathode (side plated) front face, to heighten the stirring effectiveness, and to put in many Fe(s) into a NiFe alloy, and it becomes possible to make said amount of Fe(s) contain to 80 mass %.
[0178] However, if there are too many amounts of Fe(s) in a FeNi system alloy, even if it is putting in dicarboxylic acid during the plating bath, stress cannot be eased appropriately, but it will become easy to produce film peeling according to increase of stress. And coercive force Hc also increases because the diameter of crystal grain makes it big and rough, and the fall of the soft magnetic characteristics accompanying it poses a problem.
[0179] Therefore, it is important to control appropriately the upper limit of the amount of Fe(s) in a FeNi system alloy, and the upper limit of the amount of Fe(s) is set as 80 mass % in this invention in the first half.
[0180] Moreover, it is desirable to mix 2-butine -1 and 4 diol during the plating bath of a FeNi system alloy in this invention. By this, big and rough-ization of the diameter of crystal grain of a NiFe system alloy by which plating formation was carried out is controlled, it is hard coming to generate an opening between crystals because said diameter of crystal grain becomes small, and ****** of a film surface can be controlled still more appropriately.
[0181] Moreover, it is desirable to mix a 2-ethylhexyl sodium sulfate during said plating bath in this invention. The hydrogen produced during a plating bath by this is removed by the 2-ethylhexyl sodium sulfate which is a surface active agent, and can control ****** by said hydrogen adhering to the plating film.
[0182] Moreover, although it may replace with said 2-ethylhexyl sodium sulfate and sodium lauryl sulfate may be used, it enables it for there to be little foaming when the direction which used the 2-ethylhexyl sodium sulfate mixes during a plating bath, therefore to be able to mix many said 2-ethylhexyl sodium sulfates during a plating bath, and to remove said hydrogen more appropriately. Moreover, it is also possible to reduce the membrane stress of a NiFe system alloy by addition of said 2-ethylhexyl sodium sulfate.
[0183] Below, this invention shows an usable concrete plating bath presentation and an example of a production process.

[0184] The presentation of the plating bath set and used like electrolysis galvanizer NiCl2 6 hydrate (117 g/L), NiSO4 6 hydrate (50 g/L), The saccharin Na which is NaOH (25 g/L), a boric acid (25 g/L), and a stress buffer (2 g/L) To the presentation of the conventional Watt bath which consists of a lauryl sulfuric acid Na of a surfactant (0.02 g/L), FeSO4 6 hydrate (35.7 g/L), Adding the sodium tartrate (Na2C4H4O6), the addition to the whole plating bath of the sodium tartrate is 62 - 82 mmol/L.
[0185] It sets like electrolysis galvanizer and pulse current is impressed to a plating bath by using the FeNi alloy spatter film as cathode. And it forms on cathode at the thickness of a request of the FeNi system alloy plating film, and ends like electrolysis galvanizer.
[0186] Although the membrane formation rate of the plating film becomes late gradually by increasing the addition of the sodium tartrate, if it is the addition of the above-mentioned sodium tartrate, said membrane formation rate is about 0.04 micrometer/min extent. When forming the about several micrometers plating film at such a membrane formation rate, long duration is not attained to like electrolysis galvanizer, and the thickness control by time amount is as easy as electrolysis galvanizer.
[0187] Thus, as for the manufactured soft magnetism film, the presentation ratio of Element S goes up with the increment in the addition of the sodium tartrate.
[0188] It turned out that the saturation magnetic flux density Bs of the soft magnetism film does not fall remarkably by addition of the sodium tartrate, without big according to the experimental result mentioned later, influencing each presentation ratio of Fe, nickel, and C by the addition of the sodium tartrate, while both the stress and coercive force Hc of the soft magnetism film declined with the increment in the addition of the sodium tartrate.
[0189] At by the way, the time of formation of the lower core layer 7 which shows the manufacture approach of the above-mentioned soft magnetism film to drawing 1 , and/or the up core layer 10 At the time of formation of drawing 2 , the lower magnetic pole layer 19 shown in 3, and/or the up magnetic pole layer 21 It is applied, respectively at the time of formation of the lower magnetic pole layer 50 shown in drawing 7 , and/or the up core layer 55 at the time of formation of the lower core layer 7 shown in drawing 6 , and/or the high Bs layer 47 at the time of formation of drawing 4 , the lower magnetic pole layer 32 shown in 5, and/or the up magnetic pole layer 34.
[0190] And it is possible for repeatability to, improve [plating formation] the core layer or magnetic pole layer of the thin film magnetic head of structure shown in drawing 1 thru/or drawing 7 easy moreover by using the manufacture approach of the above-mentioned soft magnetism film.
[0191] In addition, in the case of the gestalt in which the lower core layer 7, the up core layer 22, and the magnetic pole sections 18 and 30 formed with the width of recording track Tw among 40 are formed at another process like the operation gestalt shown in drawing 2 thru/or drawing 5 , it is desirable to set the amount of the sodium tartrate especially added during a plating bath as 82 or less mmol/L by 62 or more mmol/L.
[0192] In drawing 2 and the thin film magnetic head shown in 3, a resist layer is formed on the lower core layer 7, and a slot is formed in this resist layer by exposure development. and although plating formation of said magnetic pole section 18 is carried out at this Mizouchi, in order for the width method to the truck cross direction (the direction of illustration X) of said slot to correspond to narrow track-ization appropriately, it is desirable, and the dimension of depth (the direction of illustration Y) also comes out to that extent, and it is sometimes 0.1 micrometers to about 0.5 micrometers, and a height dimension (illustration Z direction) is about 5 times from the twice of a width method.
[0193] While adjusting the amount of Fe(s) appropriately so that the saturation magnetic flux density Bs of a magnetic pole layer may become high in the first half in order to carry out plating formation of the lower magnetic pole layer 19, the gap layer 20, and the up magnetic pole layer 21 appropriately into such very narrow space, stress must be made small and ****** of a film surface must be further made small. It meets, and if there is nothing, it will become impossible to also form in a predetermined configuration the layer which it becomes easy to produce film peeling, and is formed on said magnetic pole layer.
[0194] Therefore, it is desirable to adjust a plating bath presentation appropriately so that a

magnetic pole layer can be formed in this invention with a FeNi system alloy with small stress with small and ****** of a film surface. Specifically, the addition of the sodium tartrate added during a plating bath is set as 82 or less mmol/L by 62 or more mmol/L to the whole plating bath.
[0195] If it is the FeNi system alloy formed by this plating bath presentation, while being able to obtain the high saturation magnetic flux density Bs beyond 1.8T, center line average-of-roughness-height Ra of a film surface can be held down to 80A or less, and stress is made to 160 or less MPas, therefore saturation magnetic flux density Bs is high in very small space, and it enables repeatability to, improve [plating formation] the magnetic pole layer which film peeling etc. moreover does not produce easy moreover.
[0196] In addition, although the thin film magnetic head shown in drawing 1 thru/or drawing 7 as an application of a FeNi system alloy was shown in this invention, it is not limited to this application. For example, said FeNi system alloy is usable to flat-surface mold magnetic cells, such as a thin film inductor, etc.
[0197]
[Example] Next, the example of the soft magnetism film of this invention is explained. Table 1 summarizes the addition of the sodium tartrate to the whole plating bath, the presentation ratio of the plated FeNi system alloy, stress, coercive force Hc (a hard axis and easy axis), an anisotropy field, saturation magnetic flux density Bs, specific resistance, and center line average-of-roughness-height Ra of a film surface about examples 1 and 2 and the examples 1-8 of a comparison.
[0198]
[Table 1]

	酒石酸ナトリウム	組成(質量%)					異方性磁界	飽和磁束密度	比抵抗	Ra
	添加量(mmol/L)	Fe	Ni	S	C		A/m	T	μΩ・cm	Å
比較例1	0	72.397	26.843	0.094	0.818	727	69	1.91	32	83
比較例2	5	72.307	26.714	0.100	0.879	696	56	1.89	32	
比較例3	25	72.353	26.659	0.110	0.878	640	71	1.89	32	89
比較例4	37	72.164	26.850	0.116	0.870	625	135	1.88	32	
実施例1	62	72.191	26.896	0.125	0.787	477	214	1.88	32	
実施例2	82	71.947	27.102	0.132	0.819	459	245	1.88	31	76
比較例5	100	72.225	26.844	0.140	0.842	444	264	1.88	32	213
比較例6	100	80.110	18.990	0.071	0.829	膜はがれの為未測定				
比較例7	0	55.940	44.060	0.000	0.000	251	271	1.51	—	—
比較例8	0	68.000	32.000	0.000	0.000	731	61	1.80	—	—

[0199] When this table is seen, it turns out that there is no difference like ** at the value of specific resistance at each sample.

[0200] Next, the amount of Fe(s) is explained. As for the example 1 of a comparison thru/or 5, and examples 1 and 2, all are understood that the amount of Fe(s) is before and after about 72 mass %, and that also of saturation magnetic flux density Bs is before and after 1.9T.

[0201] on the other hand — the example 7 of a comparison — the amount of Fe(s) — very much — few — about 55 mass % comparable as the former — it is — saturation magnetic flux density Bs — at most — it is about 1.5T. Moreover, in the example 8 of a comparison, the amount of Fe(s) is 68 mass %, and saturation magnetic flux density Bs is going up to about 1.8T.

[0202] Moreover, in the example 6 of a comparison, although the amount of Fe(s) was more than 80 mass %, it was not able to experiment by causing film peeling.

[0203] Based on this experimental result, this invention prescribed the amount of Fe(s) as follows. First, it was larger than 55 mass %, and the amount of Fe(s) was made under into 75 mass %. It turns out that saturation magnetic flux density can be made larger than 1.5T as it is this range. Moreover, if the amount of Fe(s) is carried out more than 72 mass %, saturation magnetic flux

density can be raised even to about 1.9T.
[0204] Moreover, by this invention, the more desirable amount of Fe(s) was made below into 80 mass % above 68 mass %. Saturation magnetic flux density Bs is made more than 1.8T by this. Moreover, if the amount of Fe(s) exceeds 80 mass %, I will think that film peeling was caused by increase of stress. Therefore, the magnetic layer from which increase of below 80 mass %, then stress is reduced, and film peeling does not produce the amount of Fe(s) like this invention can be formed.
[0205] Next, as shown in Table 1, there were no various properties, such as stress, coercive force, and center line average-of-roughness-height Ra, uniformly by each sample, by this invention, are the following and were investigated about the relation between the presentation ratio of Element S, and each property, and the relation between the addition of the sodium tartrate, and each property.
[0206]
[Table 2]
膜中S組成比とStress・Hcの相関

添加量 mmol/L	S wt%	応力 Stress Mpa	保磁力 Hch (A/m)	保磁力 Hce (A/m)	異方性磁界 Hk (A/m)	Ra Å	
0	0.094	215	730	533	69	83	
5	0.100	217	695	472	56		
15	0.098	219	625	395	53		
25	0.110	218	640	416	71	89	
37	0.116	216	625	448	134		
62	0.125	160	477	280	213		
82	0.132	155	459	161	245	75	↑面荒れ問題無し
100	0.141	151	367	159	308	213	↓Ra大(面荒れ)につきNG

[0207] Table 2 is the experimental result of the sample which is to create the graph of drawing 8 and drawing 9 , and was used. Although Table 2 extracts and displays the experimental result of the examples 1, 2, 3, 4, and 5 of a comparison shown in Table 1, and examples 1 and 2, it has newly added further the experiment sample which made the addition of the sodium tartrate 15 mmol/L to this table 2. In creating drawing 8 and 9, in Table 2, a required experimental result, i.e., the presentation ratio of S of each sample, stress, coercive force, etc. are indicated.
[0208] Each sample in Table 2 is obtained here using the following plating bath presentations. The presentation of the plating bath set and used like electrolysis galvanizer NiCl2 6 hydrate (117 g/L), NiSO4 6 hydrate (50 g/L), The saccharin Na which is NaOH (25 g/L), a boric acid (25 g/L), and a stress buffer (2 g/L) To the presentation of the Watt bath which consists of a lauryl sulfuric acid Na of a surfactant (0.02 g/L), FeSO4 6 hydrate (35.7 g/L), Adding the sodium tartrate (Na2C4H4O6), the addition to the whole plating bath of the sodium tartrate is 0 - 100 mmol/L. Moreover, plating formation was carried out using electrolysis plating using pulse current.
[0209] In addition, all the experimental results after the following drawing 8 are obtained by this experiment approach.
[0210] Drawing 8 is a graph which shows stress (MPa) and the relation of the element S presentation ratio (mass %) contained in the FeNi system alloy. It turns out that stress declines, so that the presentation ratio of Element S increases. As shown in drawing 8 , it turns out that the stress of a FeNi system alloy can decline rapidly within the section of 0.116 mass % to 0.125 mass %, and the presentation ratio of Element S can set stress to 210 or less MPas. Moreover, although there is no fall as the section of 0.116 mass % to 0.125 mass % when the presentation ratio of said element S is made [more] than 0.125 mass %, it turns out that said stress can be reduced further.
[0211] Drawing 9 is a graph which shows the relation of the presentation ratio (mass %) of the element S contained in coercive force Hc (A/m) and a FeNi system alloy. As shown in drawing 9 ,

when coercive force Hc declines gradually with the increment in the presentation ratio of Element S and carries out the presentation ratio of Element S more than 0.116 mass %, the degree of a fall of coercive force Hc becomes large, and it turns out that coercive force Hce of the direction of an easy axis is made to about 600 or less A/m by the coercive force Hch of the direction of a hard axis at the about 470 (A/m) following.

[0212] Drawing 10 is a graph which shows the relation between stress (MPa) and coercive force Hc (A/m). All the presentation ratios of Fe of the sample in this graph are being fixed to about 72 mass %.

[0213] As shown in drawing 10 , the coercive force Hc of the examples 1 and 2 shown in Table 1 is low stress compared with the example of a comparison, and it turns out that it is the low coercive force Hc.

[0214] Drawing 11 is a graph which shows the relation of S presentation ratio (mass %) contained in saturation magnetic flux density Bs (T) and a FeNi system alloy. In addition, this graph is created based on the experiment sample fixed to about 72 mass % in the amount of Fe(s).

[0215] If Element S is below 0.140 mass % extent although saturation magnetic flux density Bs has the inclination to fall a little, with the increment in the presentation ratio of Element S as shown in drawing 11 , it turns out that the saturation magnetic flux density Bs before and behind 1.9T is maintained.

[0216] Drawing 12 is a graph which shows the relation of the presentation ratio (mass %) of an anisotropy field (A/m) and Element S. In addition, this graph is created based on the experiment sample fixed to about 72 mass % in the amount of Fe(s).

[0217] As shown in drawing 12 , as for an anisotropy field, it turns out that it is going up with the increment in the presentation ratio of Element S, and soft magnetic characteristics improve with the increment in the presentation ratio of S.

[0218]

[Table 3]

添加量 mmol/L	C wt%	Ni wt%	Fe wt%	S wt%	Total wt%	Ra Å
0	0.818	26.843	72.392	0.094	100	83
5	0.879	26.714	72.307	0.1	100	
15	0.8	26.82	72.283	0.098	100	
25	0.878	26.659	72.353	0.11	100	89
37	0.87	26.85	72.164	0.116	100	
62	0.787	26.896	72.191	0.125	100	
82	0.819	27.102	71.947	0.132	100	75
100	0.83	27.068	71.961	0.141	100	213

[0219] Table 3 is the experimental result of each sample which was used in creating following drawing 13 thru/or following drawing 15 . In addition, although the experimental result of the examples 1, 2, 3, 4, and 5 of a comparison shown in Table 1 and examples 1 and 2 is extracted and displayed like Table 2, the experiment sample which made the addition of the sodium tartrate 15 mmol/L further is newly added. In creating drawing 13 thru/or 15, in Table 3, the required experimental result, i.e., the presentation ratio of S of each sample, C presentation ratio, Fe presentation ratio, etc. are indicated.

[0220] Drawing 13 -15 are a graph which shows the addition (mmol/L) of the sodium tartrate, and the relation of the presentation ratio of S, the presentation ratio of Fe, and the presentation ratio (mass %) of C. As shown in drawing 13 , it turns out that S presentation ratio becomes high gradually by adding the sodium tartrate to a plating bath.

[0221] Moreover, as shown in drawing 14 , it turns out that the presentation ratio of Fe falls a little by adding the sodium tartrate to a plating bath, and ** keeps each the amount of Fe(s) before and behind 72 mass % with the sample used for the experiment.

[0222] Moreover, as shown in drawing 15 , it turns out that the presentation ratio of C is hardly dependent on the addition of the sodium tartrate.
[0223] Drawing 16 is the graph which showed the relation between the addition of the sodium tartrate, and the stress of a FeNi system alloy. As shown in drawing 16 , when the addition of the sodium tartrate is made into within the limits of 37 mmol/L to 62 mmol/L, it turns out that the stress of a FeNi system alloy declines rapidly. Moreover, although it is not a rapid fall like this, it turns out that the fall of said stress can be aimed at for the addition of said sodium tartrate as for 62 or more mmol/L.
[0224] Drawing 17 is a graph which shows the addition of the sodium tartrate, and the coercive force Hc (a hard axis, easy axis) of a FeNi system alloy and relation with saturation magnetic flux density Bs. As shown in drawing 17 , when the addition of the sodium tartrate is made into 37 or more mmol/L, it turns out that said coercive force Hc can be reduced effectively.
[0225] On the other hand, although saturation magnetic flux density Bs falls gradually by addition of said sodium tartrate, it turns out that the saturation magnetic flux density Bs before and behind 1.9T is maintained.
[0226] Drawing 18 is a graph which shows the relation between the addition of the sodium tartrate, and the anisotropy field Hk of a FeNi system alloy. As shown in drawing 18 , it turns out that said anisotropy field can be raised by addition of the sodium tartrate, and the FeNi system alloy excellent in soft magnetic characteristics can be formed.
[0227] Drawing 19 is a graph which shows the relation between the membrane formation rate like electrolysis galvanizer, and the addition of the sodium tartrate. Although a membrane formation rate falls a little by carrying out the addition of the sodium tartrate, it maintains the membrane formation rate of 0.040 or more micrometer/min in the range where the addition of said sodium tartrate is lower than 100 mmol/L, and is considered not to have big effect on a plating process.
[0228] By raising the presentation ratio of the element S contained in a FeNi system alloy, I hear that that I understand from the above experimental result can aim at reduction of stress and coercive force Hc, and there is (please refer to drawing 8 and 9). Although Fe presentation ratio was the same on the other hand, even when Elements S differed, it turned out that saturation magnetic flux density Bs is so much changeless (refer to drawing 11), and an anisotropy field can be raised and improvement in soft magnetic characteristics can be aimed at by addition of Element S.
[0229] So, in this invention, rather than 0.116 mass %, the presentation ratio of the element S contained in a FeNi system alloy based on the above-mentioned experimental result was made into many range, and was more preferably set up more than 0.125 mass %.
[0230] It turned out that reduction of the stress of a FeNi system alloy and coercive force Hc can be aimed at by raising the addition of said sodium tartrate also in the addition of the sodium tartrate under plating bath again (please refer to drawing 16 and 17). Moreover, although the content of the element S in a FeNi system alloy rose by addition of the sodium tartrate, it turned out that, as for the amount of Fe(s), the fall like ** is not seen (refer to drawing 13 and 14), and saturation magnetic flux density Bs does not fall greatly by addition of the sodium tartrate as it is shown in drawing 17, since change is not looked at so much by addition of the sodium tartrate in this way by the amount of Fe(s). Moreover, it turned out that an anisotropy field can be raised and improvement in soft magnetic characteristics can be aimed at by addition of the sodium tartrate.
[0231] So, in this invention, rather than 37 mmol/L, the addition of the sodium tartrate added during a plating bath based on the above-mentioned experimental result was made into many range, and was more preferably set as 62 or more mmol/L.
[0232] Next, the upper limit of the element S contained in a FeNi system alloy and the upper limit of the sodium tartrate added during a plating bath are explained below.
[0233] As shown in Table 1, in the case of the example 1 of a comparison, center line average-of-roughness-height Ra of a film surface was about 83A, in the case of the example 4 of a comparison, said center line average-of-roughness-height Ra was about 89A, in the case of the example 2, said center line average-of-roughness-height Ra was about 75A, and, in the case of the example 5 of a comparison, said center line average-of-roughness-height Ra was about 213A.
[0234] The addition of the sodium tartrate in the four above-mentioned samples is looked at. The

example 3 of a comparison is 25 mmol/L, the example 1 of a comparison is 0 mmol/L, and the example 5 of a comparison is [an example 1 is 82 mmol/L and] 100 mmol/L.
[0235] Center line average-of-roughness-height Ra of the above-mentioned film surface will fall, if the addition of this sodium tartrate is optimum dose, but if the addition of said sodium tartrate increases too much, if the addition of said sodium tartrate exceeds 82 mmol/L, in this experiment, it will be thought conversely that said Ra becomes large. It is considered that it is one cause that a membrane formation rate becomes late by the increment in the addition of said sodium tartrate explained by drawing 19 .
[0236] The thing small as much as possible of center line average-of-roughness-height Ra of a film surface is desirable. Center line average-of-roughness-height Ra becomes large, namely, if ****** becomes severe, a corrosion resistance fall and the problem that the magnetic layer of a predetermined configuration cannot be formed further will occur.
[0237] So, the upper limit of the addition of the sodium tartrate was made into less than 100 mmol/L in this invention. It turns out that center line average-of-roughness-height Ra of a film surface can be held down to about 200A or less by this. The addition of said sodium tartrate is 82 or less mmol/L more preferably. It turns out that said center line average-of-roughness-height Ra can be held down to about 80A or less by this.
[0238] Therefore, in this invention, rather than 37 mmol/L, and the addition of the sodium tartrate was set up with less than 100 mmol/L. Moreover, the more desirable range was set as 82 or less mmol/L by 62 or more mmol/L.
[0239] Moreover, when less than 100 mmol/L of additions of said sodium tartrate is preferably made into 82 or less mmol/L, drawing 13 shows that the content of the element S in a FeNi system alloy is under 0,140 mass %. Moreover, when the addition of said sodium tartrate is made into 82 or less mmol/L, it turns out that the content of Element S is made to below 0.132 mass %.
[0240] By this invention, by this experimental result, and the presentation ratio of the element S in said FeNi system alloy was specified under as 0.140 mass %, and was preferably specified below as 0.132 mass % rather than 0.116 mass % by it above 0.125 mass %.
[0241] Next, a corrosion resistance experimental result is explained below. In the experiment, the magnetic pole section of a configuration as shown in drawing 20 was formed. The bottom layer is the Fe20nickel80 alloy film, and plating formation of the Hi-B (lower magnetic pole layer) film which has the high saturation magnetic flux density Bs on it, the NiP (gap layer) film, and the Hi-B (up magnetic pole layer) film was carried out.
[0242]
[Table 4]

酒石酸ナトリウム添加量 [m mol/L]	腐食発生素子数 純水 pH=4.7 (10min)	腐食発生素子数 希硫酸 pH=2.0 (1min)	組成(wt%) C	Ni	Fe	S
0	0個/10個	4個/10個	0.818	26.843	72.392	0.094
82	0個/10個	3個/10個	0.819	27.102	71.947	0.132

[0243] By this invention, plating formation of the two Hi-B film was carried out by two magnetic layers mentioned to Table 4. One side is the FeNi system alloy with which the FeNi system alloy formed considering the sodium tartrate of a under [a plating bath] as 0 mmol/L and another side were formed considering the sodium tartrate of a under [a plating bath] as 82 mmol/L. In addition, it prepared each ten samples at a time.
[0244] The sample which the sample which becomes the pure water of pH=4.7 from the cascade screen of drawing 20 is made immersed for 10 minutes, and becomes the dilute sulfuric acid of pH=2.0 from the cascade screen of drawing 20 was made immersed for 1 minute in an experiment. And the condition of corrosion was measured.
[0245] As shown in Table 4, when the sample of a cascade screen using the FeNi system alloy formed considering the sodium tartrate as 0 mmol/L as Hi-B film and the sodium tartrate were dipped in pure water by the sample of a cascade screen using the FeNi system alloy formed as 82 mmol/L as Hi-B film, corrosion was seen by neither of the samples. On the other hand, although the sample by which either of the samples was corroded among ten samples each was below one

half when it dipped in a dilute sulfuric acid, four samples formed considering the sodium tartrate as 0 mmol/L were three corrosion by the sample formed considering the addition of the sodium tartrate as 82 or less mmol/L to having been corroded.
[0246] Thus, it turned out that the plating formation of the FeNi system alloy which was excellent in 82 or less mmol/L, then corrosion resistance in the addition of the sodium tartrate can be carried out. With the FeNi system alloy formed considering the addition of the sodium tartrate as 82 or less mmol/L, this is considered to be because for center line average-of-roughness-height Ra of a film surface to have been made small. Specifically, said center line average-of-roughness-height Ra is made to 80A or less (please refer to Table 1 etc.).
[0247] Finally, the relation between the sample used for the experiment, and the diameter of crystal grain and crystal orientation was investigated. The experimental result is shown in Table 5.
[0248]
[Table 5]
その他諸特性

添加量	ρ	XRD		
mmol/L	μΩ・cm	(111)反射回折線幅	(200)／(111)回折線強度比	(220)／(111)回折線強度比
0	32	1.51	0.17	0.059
5	32			
15	32	1.55	0.187	0.049
25	32			
37	32	1.52	0.169	0.059
62	32			
82	31	1.55	0.17	0.059
100	32			

↑ 電気特性(比抵抗値)の変化なし　↑ 結晶粒径の変化なし　↑ 配向の変化なし

[0249] Although the magnitude of the diameter of crystal grain can be predicted by the experimental result of the reflective circuit width of face in Table 5 (111), reflective (111) circuit width of face is considered that are changeless, therefore there is almost no change in the diameter of crystal grain of a FeNi system alloy by the addition of the sodium tartrate. If the diameter of crystal grain becomes small as already stated, generally the fall of stress will be seen, but if it carries out from this experimental result, it will be thought that the fall of the stress by content of Element S is almost unrelated to the size of the diameter of crystal grain. moreover, crystal orientation -- each sample -- most -- it was changeless.
[0250]
[Effect of the Invention] The soft magnetism film of this invention is a FeNi system alloy containing S, and the presentation ratio of S exceeds 0.116 mass %, and it is under 0.140 mass %.
[0251] Since stress and coercive force Hc decline with the increment in the presentation ratio of S when the presentation ratio of S is under 0.140 mass % exceeding 0.116 mass %, such soft magnetism film is compatible in low stress and outstanding soft magnetic characteristics. Moreover, ****** of a film surface can be made small.
[0252] Moreover, in this invention, the presentation ratio of Fe is larger than 55 mass %, and it is under 75 mass %, or is below 80 mass % preferably above 68 mass %. By this, saturation magnetic flux density is preferably made more than 1.8T more than 1.6T, moreover, maintaining this high saturation magnetic flux density, according to this invention, stress can be made low, coercive force can be made low, and ****** of a film surface can be further made small.
[0253] Moreover, the manufacture approach of the soft magnetism film of this invention is the approach of forming the FeNi system alloy containing S with electrolysis plating, the presentation of the plating bath used like electrolysis galvanizer contains the solution containing Fe ion, nickel ion, and S ion, and dicarboxylic acid is added further.
[0254] It is desirable that it is the sodium tartrate, at this invention, the addition of the sodium tartrate to said whole plating bath exceeds 37 mmol/L, and, as for said dicarboxylic acid, it is specifically desirable that they are less than 100 mmol/L. They are 82 or less mmol/L in 62 or

more mmol/L more preferably.
[0255] By such manufacture approach of the soft magnetism film, since the sodium tartrate was added to the plating bath, S can deposit in the plating film and the FeNi alloy plating film containing S can be manufactured. And while being able to make low effectively the above-mentioned stress and the coercive force of a FeNi system alloy by which plating formation was carried out to it being the addition of the sodium tartrate, center line average-of-roughness-height Ra of a film surface can be effectively made small.
[0256] Moreover, the gap layer which the thin film magnetic head of this invention is formed on a lower core layer and this lower core layer, and consists of an insulating material, It is formed on this gap layer and has the coil layer which consists of a right electrical conducting material, and the up core layer formed on this insulator layer with the wrap insulating layer in this coil layer. To said up core layer and a lower core layer The record field was guided according to the current impressed to said coil layer, and the above-mentioned soft magnetism film was used at least for one side among said up core layers and lower core layers.
[0257] Since the soft magnetism film used as an up core layer or/, and a lower core layer is low stress and the low coercive force Hc compared with the conventional soft magnetism film with the equivalent presentation ratio of Fe, the adhesion of a lower core layer, an insulating layer or/and an up core layer, and a gap layer and the dependability of the thin film magnetic head [such] of record data improve, and it becomes possible to manufacture the thin film magnetic head which can respond to high recording density-ization.

[Translation done.]

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3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing of longitudinal section of the thin film magnetic head,
[Drawing 2] The partial front view of the thin film magnetic head of other operation gestalten of this invention,
[Drawing 3] Drawing of longitudinal section of drawing 2 ,
[Drawing 4] The partial front view of the thin film magnetic head of other operation gestalten of this invention,
[Drawing 5] Drawing of longitudinal section of drawing 4 ,
[Drawing 6] Drawing of longitudinal section of the thin film magnetic head of other operation gestalten of this invention,
[Drawing 7] Drawing of longitudinal section of the thin film magnetic head of other operation gestalten of this invention,
[Drawing 8] The graph which shows the stress of the soft magnetism film of this invention, and the relation of S presentation ratio.
[Drawing 9] The graph which shows the coercive force Hc of the soft magnetism film of this invention, and the relation of S presentation ratio.
[Drawing 10] The graph which shows the relation between the stress of the soft magnetism film of this invention, and coercive force Hc.
[Drawing 11] The graph which shows the saturation magnetic flux density Bs of the soft magnetism film of this invention, and the relation of S presentation ratio.
[Drawing 12] The graph which shows the anisotropy field of the soft magnetism film of this invention, and the relation of S presentation ratio.
[Drawing 13] The graph which indicates the relation of the sodium-tartrate addition of a plating bath to be S presentation ratio of the soft magnetism film of this invention.
[Drawing 14] The graph which indicates the relation of the sodium-tartrate addition of a plating bath to be Fe presentation ratio of the soft magnetism film of this invention.
[Drawing 15] The graph which indicates the relation of the sodium-tartrate addition of a plating bath to be C presentation ratio of the soft magnetism film of this invention.
[Drawing 16] The graph which shows the stress of the soft magnetism film of this invention, and the relation of the sodium-tartrate addition of a plating bath.
[Drawing 17] The graph which shows the coercive force Hc of the soft magnetism film of this invention, and the relation of the sodium-tartrate addition of a plating bath.
[Drawing 18] The graph which shows the anisotropy field Hk of the soft magnetism film of this invention, and the relation of the sodium-tartrate addition of a plating bath.
[Drawing 19] The graph which shows the membrane formation rate of the plating process of the soft magnetism film of this invention, and the relation of the sodium-tartrate addition of a plating bath.
[Drawing 20] The sectional view showing the structure of the cascade screen used for the experiment of Table 4,
[Drawing 21] The graph which shows the relation between the stress of the soft magnetism film, and coercive force Hc it is unrelated from the FeNi alloy in the former.

[Description of Notations]
h2 The head section for record
G A write-in gap
7 Lower Core Layer
8 Gap Layer
9 Coil Layer
10 Up Core Layer
11 Insulating Layer
18 30 Magnetic pole section
19, 32, 50 Lower magnetic pole layer
21 34 Up magnetic pole layer
47 High Bs Layer
48 Upper Layer

[Translation done.]

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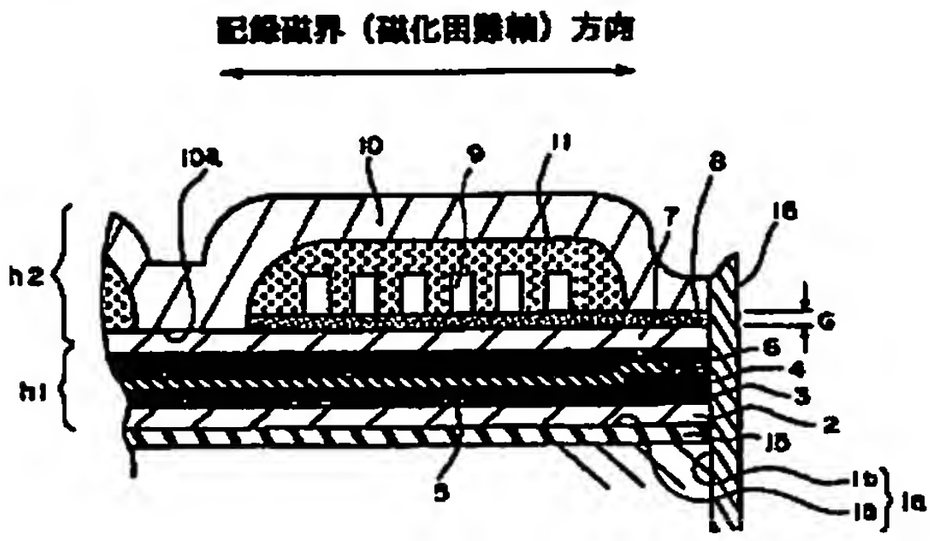
DRAWINGS

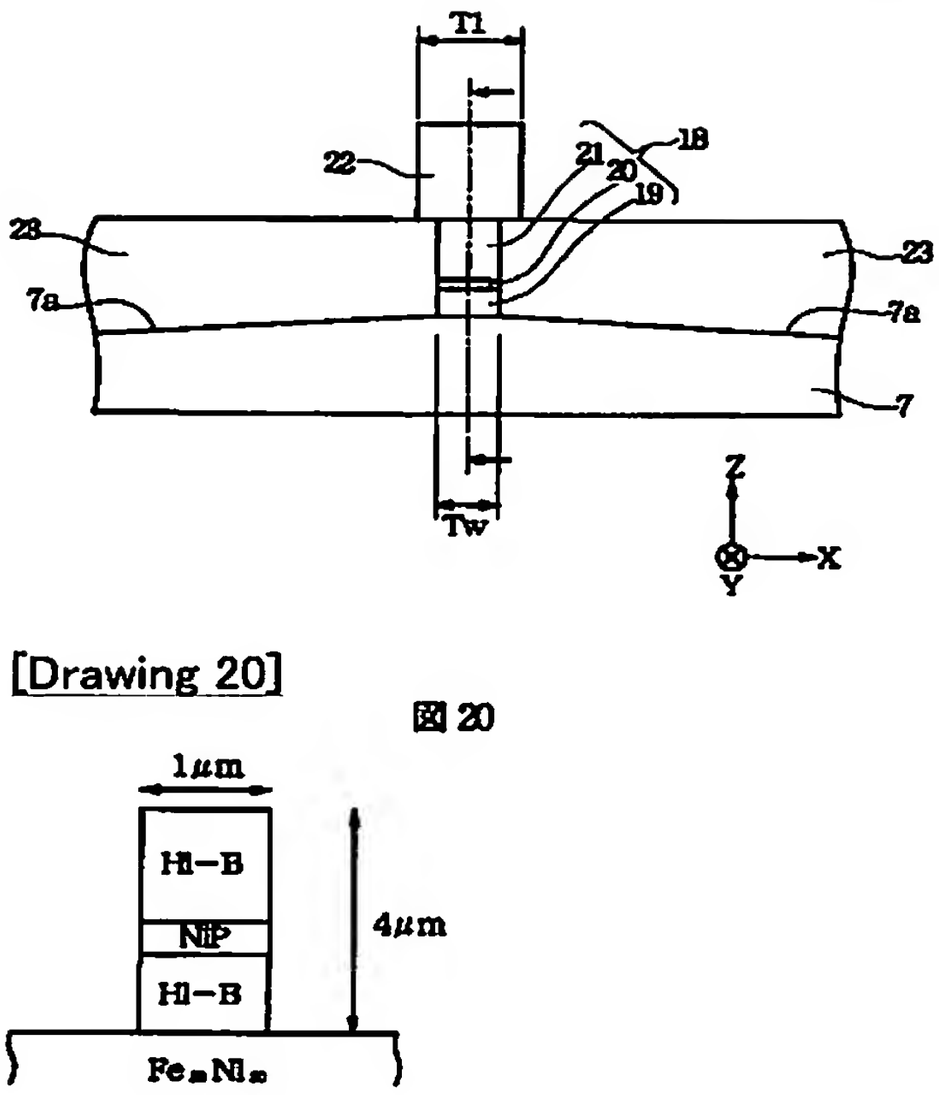
[Drawing 1]

【図1】



[Drawing 2]

図2

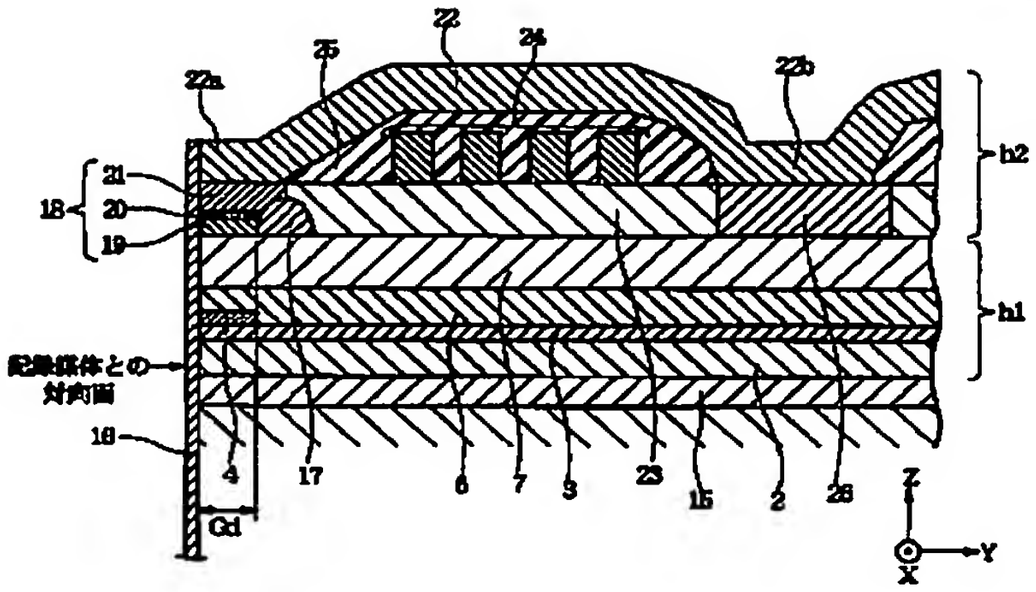


[Drawing 20]

図20

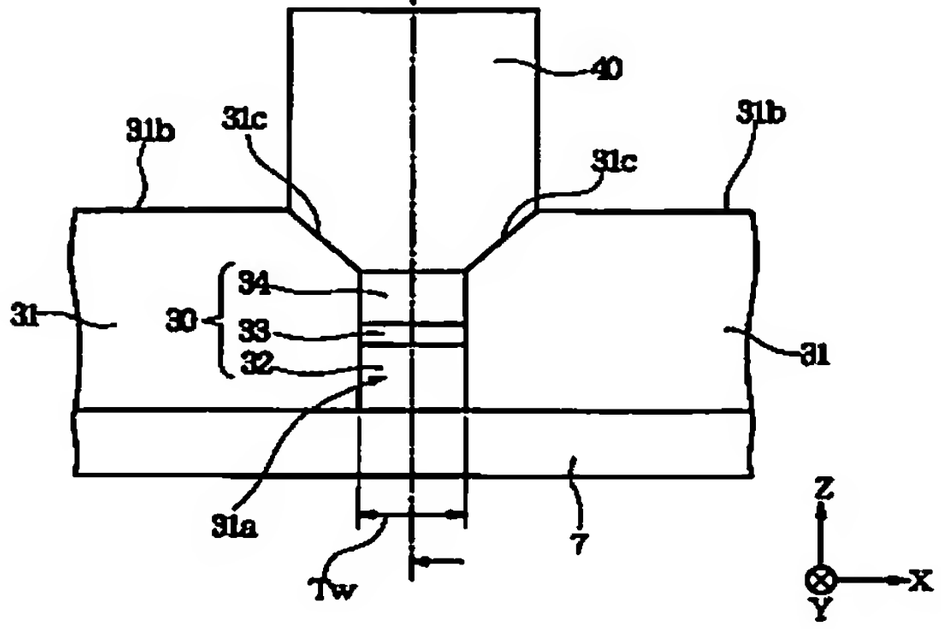
[Drawing 3]

図3



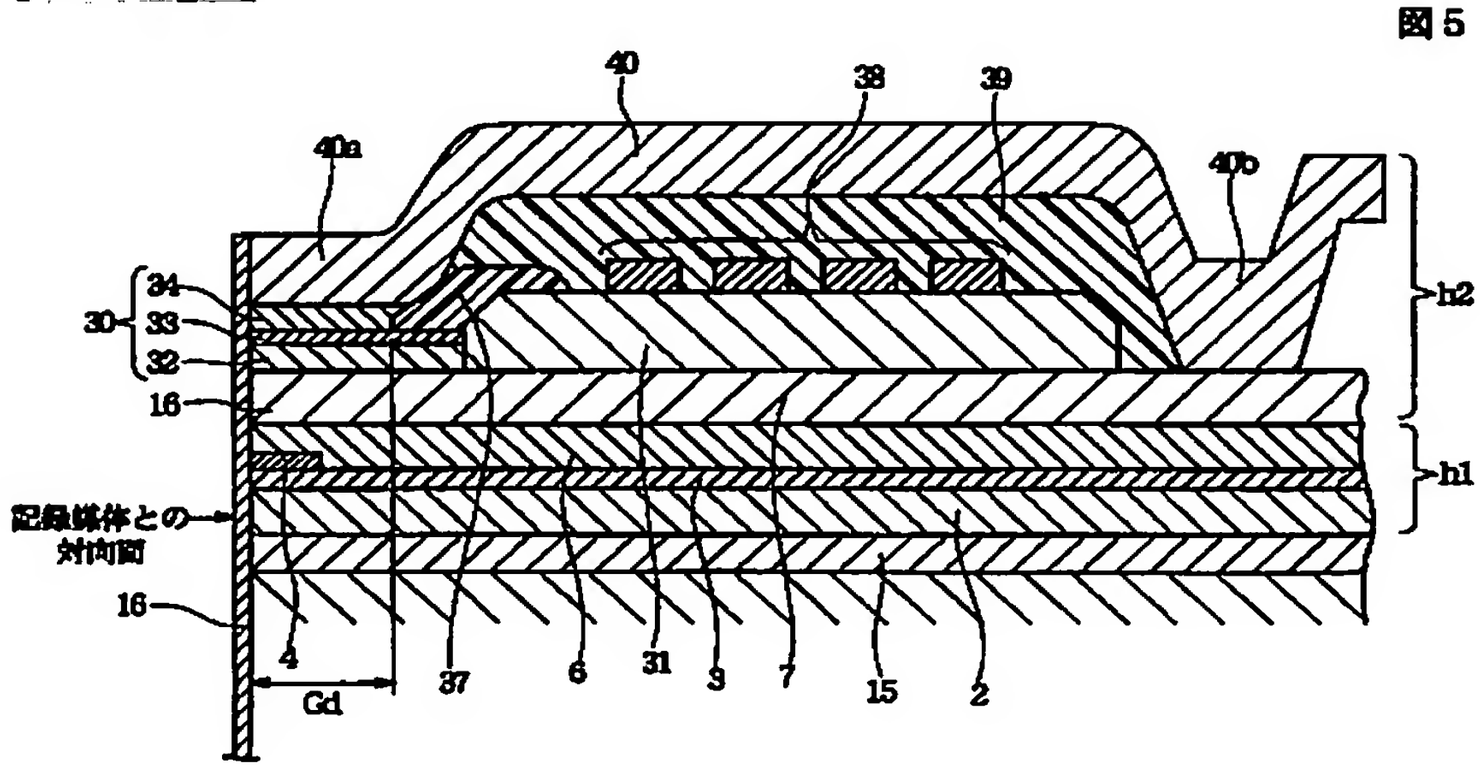
[Drawing 4]

図4



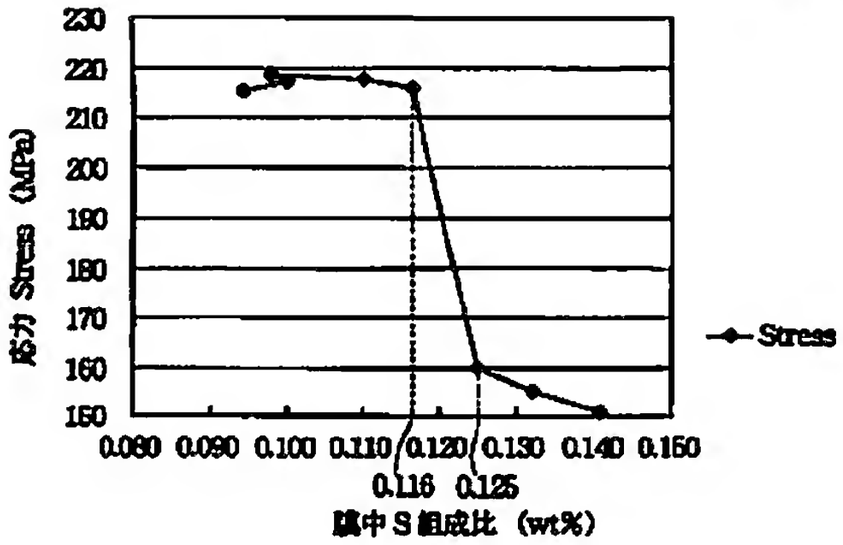
[Drawing 5]

図5



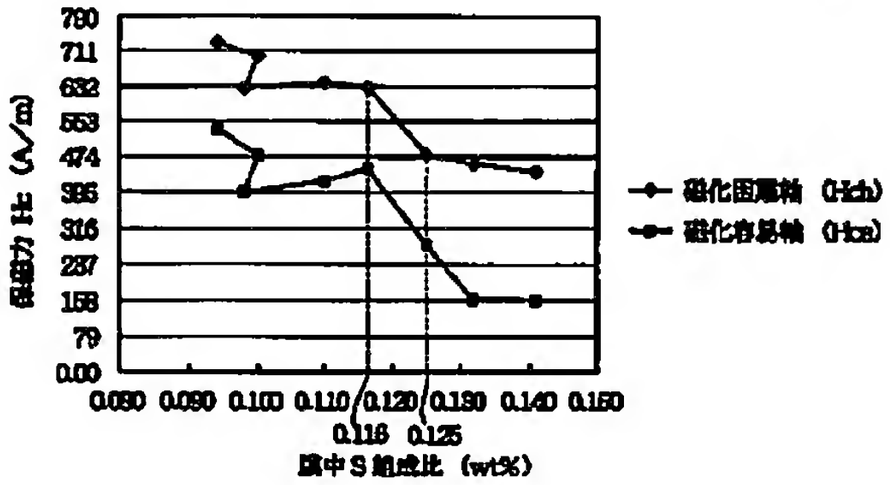
[Drawing 8]

図8



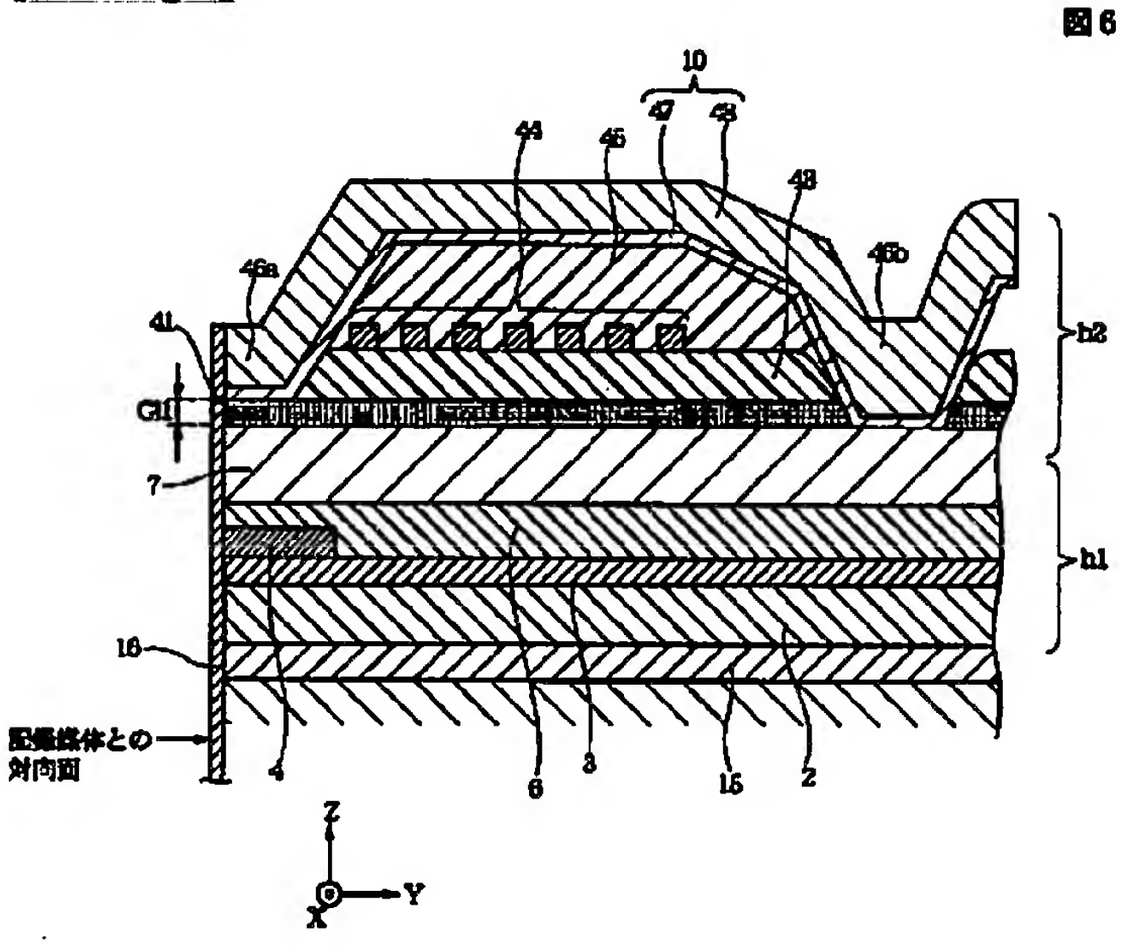
[Drawing 9]

図9



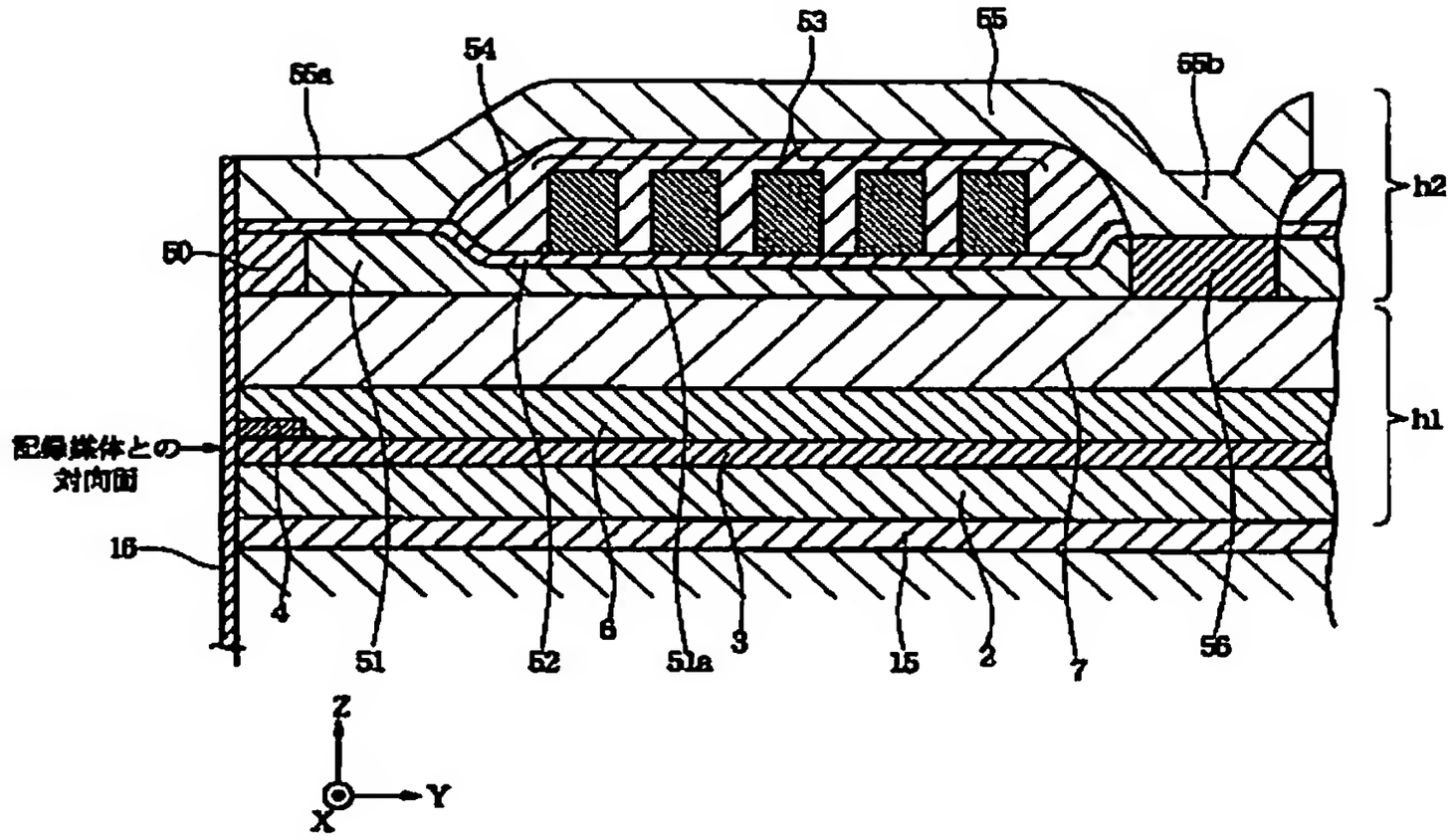
[Drawing 6]

図6



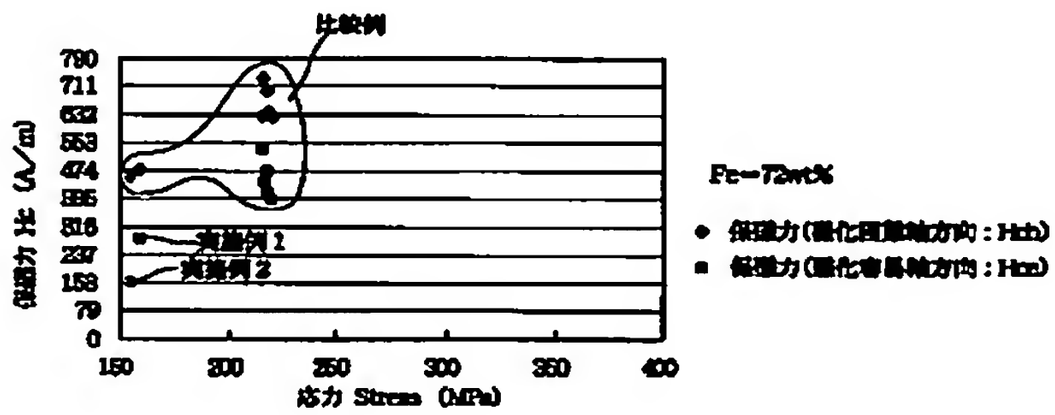
[Drawing 7]

図 7



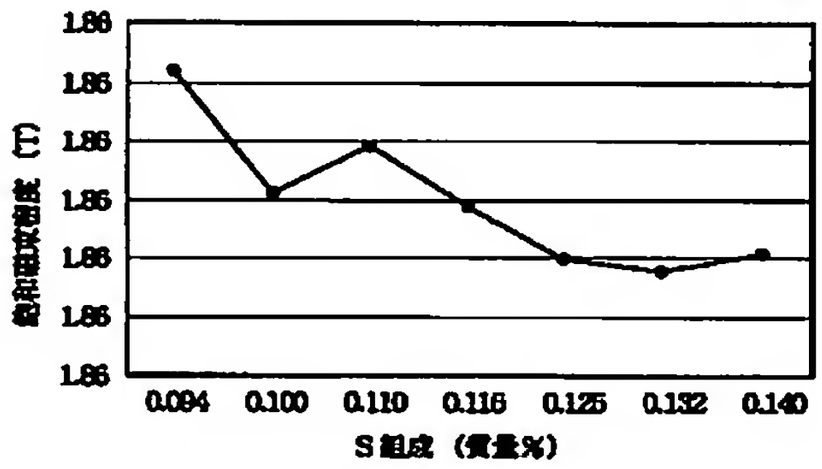
[Drawing 10]

図 10



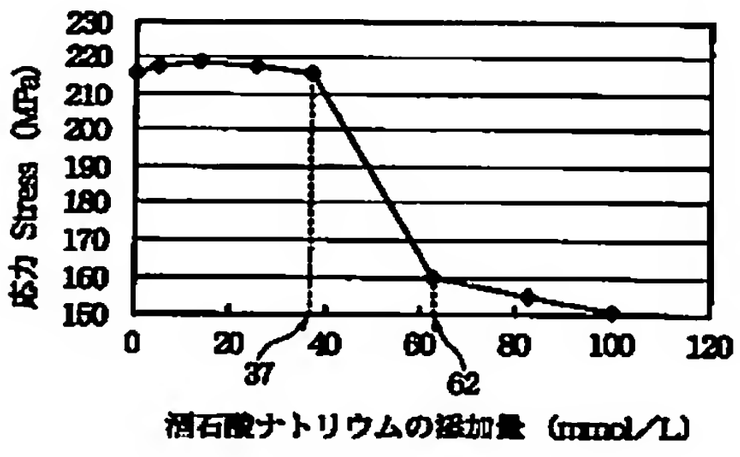
[Drawing 11]

図 11



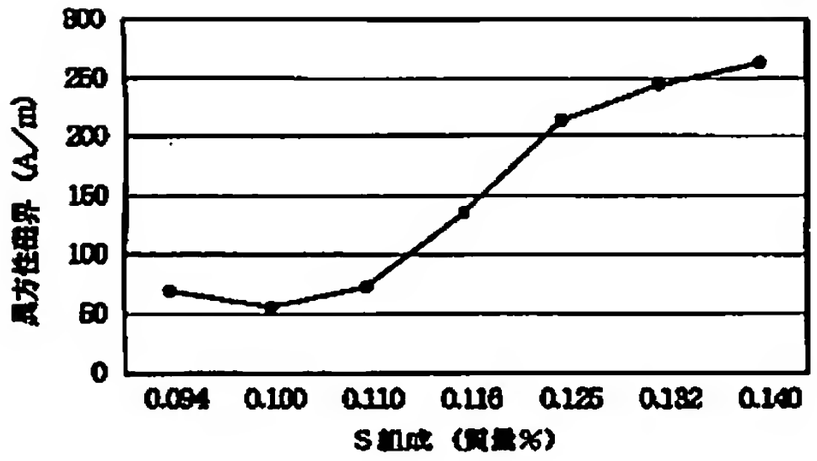
[Drawing 16]

図 16



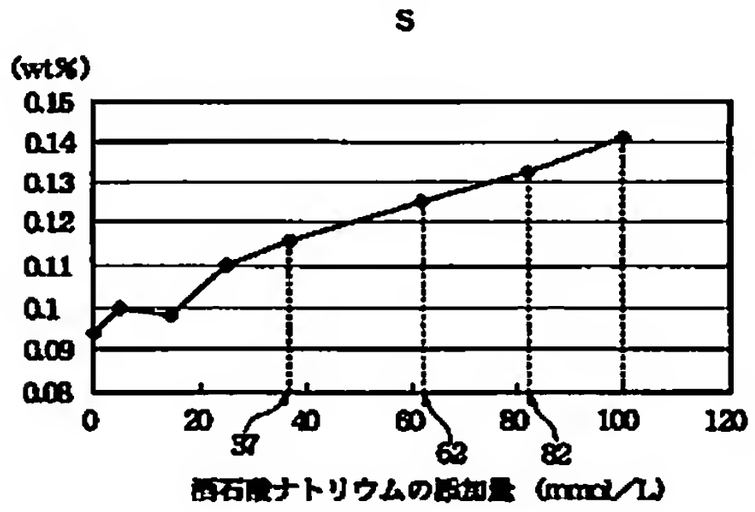
[Drawing 12]

図 12



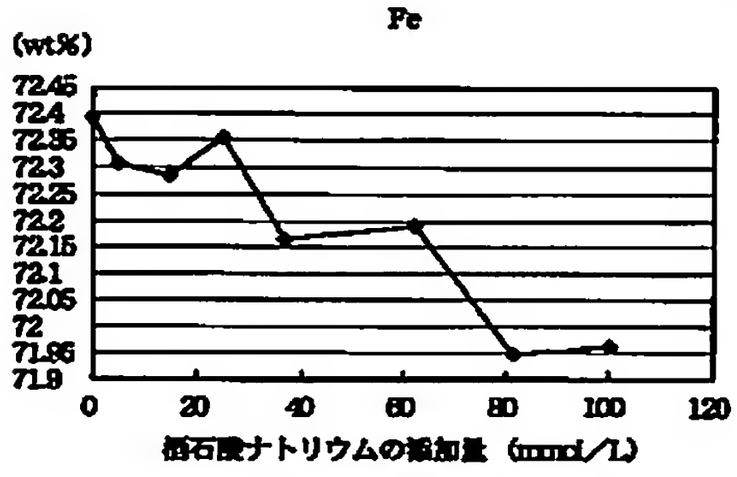
[Drawing 13]

図 13



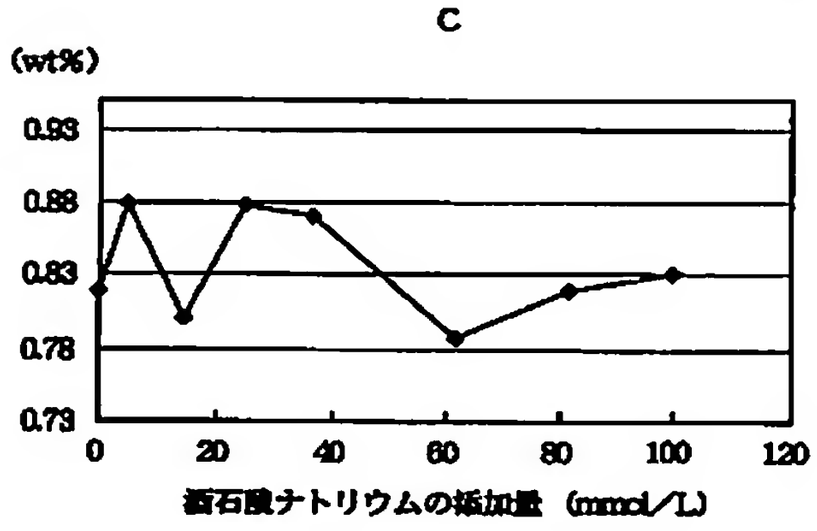
[Drawing 14]

図 14



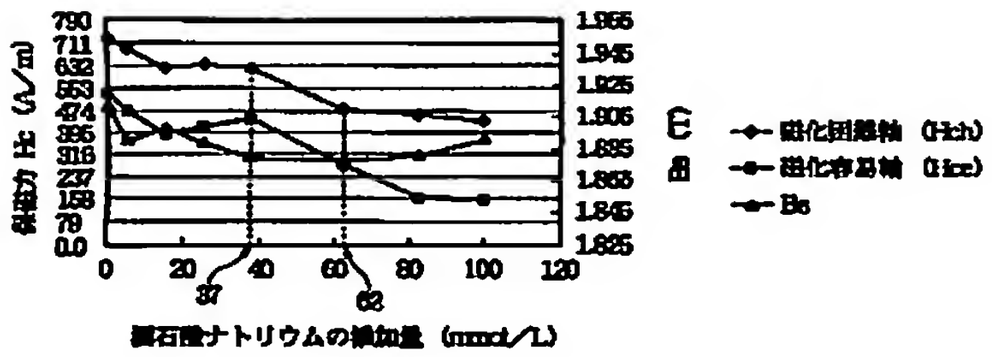
[Drawing 15]

図 15



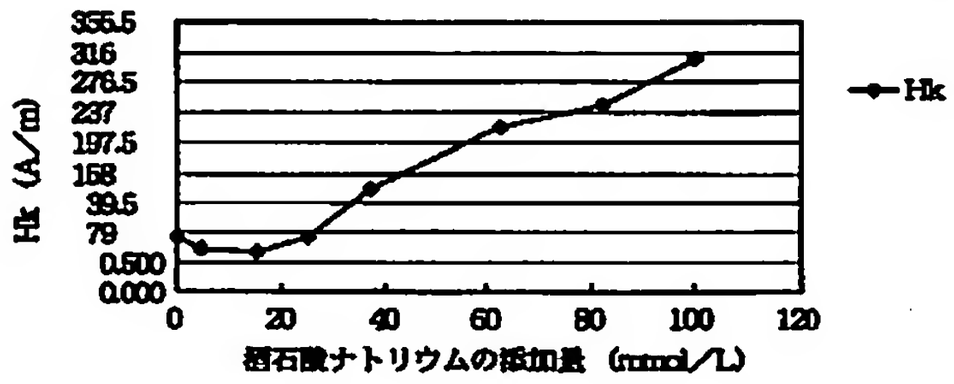
[Drawing 17]

図 17



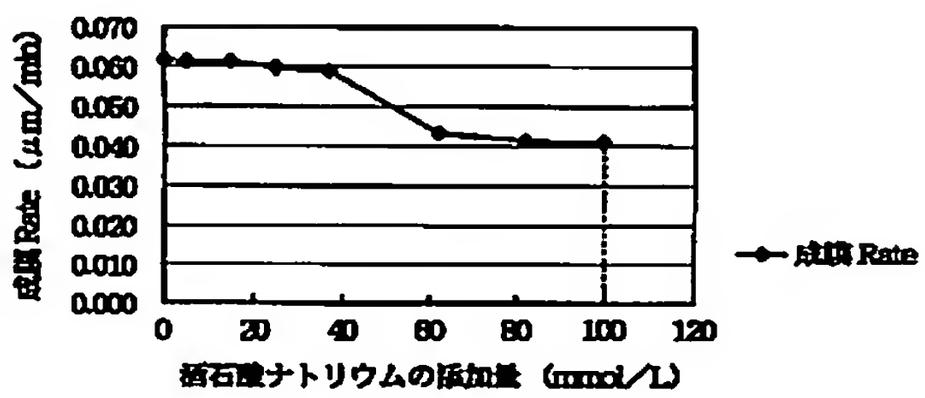
[Drawing 18]

図 18



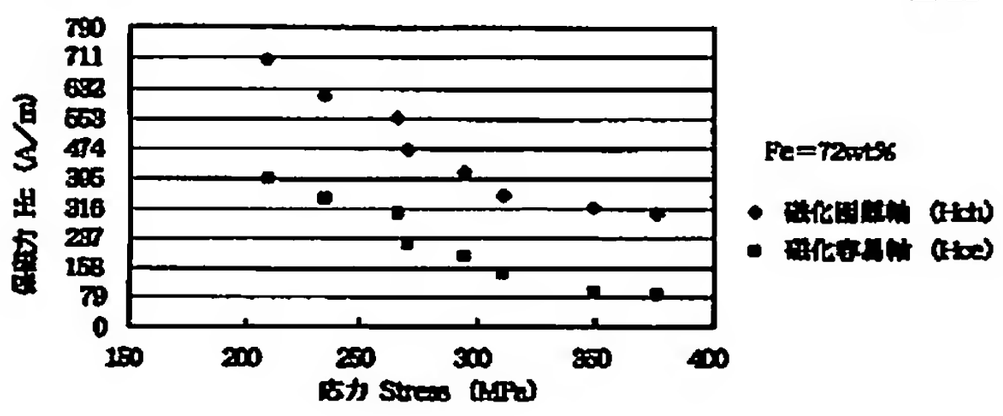
[Drawing 19]

図 19



[Drawing 21]

図 21



[Translation done.]